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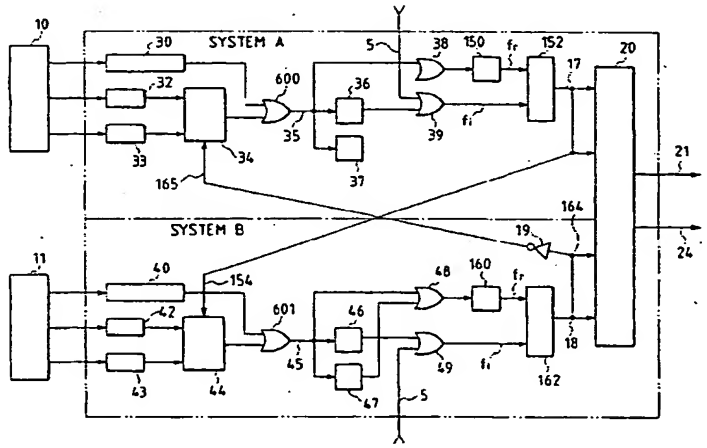
(54) Controller having a fail safe function, automatic train controller, and system using the same

(57) The object of the present invention is to provide a controller and a system having a highly reliable fail safe function. An ATP device which generates control data for the two systems from an ATP command speed signal, duplicates the logic unit in the ATP device so as to process each control data, provides at least two CRC data for checking the control data for each system, and changes the CRC data of the opposite logic units or selects one of the two according to the content of a failure detection signal from each of the duplicated logic units. It is realized to check the control data and the operation of each logic circuit and only when all the data, circuits, and elements operate normally, an output signal for controlling the object to be controlled is outputted and when a failure is detected in a part, an output signal is outputted. Therefore, when a failure occurs, a fail safe function for controlling on the safety side is made possible.

FIG. 18



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Description

[0001] The present invention relates to a circuit having a fail safe function and a controller and system using it and particularly to train control systems such as an ATP (automatic train protection) device having a fail safe function suited to a train maintenance system, an ATS (automatic train stop) device, and an ATO (automatic train operation) device,and a controller and system using them.

[0002] As the electronic technology has been developed recently, advanced and complicated control has been required so as to improve the energy (fuel) efficiency, operability, comfortability to ride in, and safety and to increase the speed in transport facilities such as airplane, train, and automobile.

[0003] On the other hand, a safety operation is necessary in those transport facilities and the reliability and fail safety (when a failure occurs, it is necessary that no output is routed from the dangerous side) of a controller are strongly required.

[0004] For example, the safety of a train operation is ensured by a superior maintenance system such as an ATC device and an ATS device.

[0005] As shown in an example of an ATP device used in the maintenance system of super-express trains, the reliability and fail safety are appreciated both at home and abroad.

[0006] An ATP device and an ATS device of those trains comprise a control circuit and relay including LSIs having a self check function mainly. A main signal used in those devices is a frequency signal in which the logical level is changed to H or L alternately (hereinafter called an alternating signal).

[0007] The control circuit compares and processes an ATP speed command signal from the ground and an actual speed signal of a train when it receives this ATP signal, controls the braking force by a speed control signal, that is, a brake command signal according to the deviation between the ATC signal and the actual speed signal, and controls the speed of the train.

[0008] A device for generating such an alternating signal is described in Japanese Patent Application Laid-Open 57-62702.

Lately, a system for transferring information on a train operation (for example, the speed and position of a train) between the central control command room and a train and exchanging information between trains is under construction so as to improve transport services and control of a higher density train operation and a higher speed train operation are required.

[0009] To respond to these requests, the controller in use at present and LSIs used for it alone are deficient in the functions of processing speed and data storage capacity and to make up for them, it is necessary to add many peripheral circuits and hence the controller is complicated.

[0010] Since the technology of semiconductors has made remarkable progress recently and high integration and high speed have been realized, a control circuit having various functions can comprise one chip of LSI.

[0011] However, in an LSI structured like this, there is a problem imposed that a wrong control signal due to mixed contact between the conductors formed inside it is outputted or a signal induced via a spray capacity between a disconnected conductor and its adjacent conductor is outputted and a control signal which can be seen as if it is normal is outputted though the LSI itself is damaged.

[0012] Furthermore, the use environment of an LSI for train control is extremely severe compared with that of an LSI for public welfare.

[0013] A serious problem arises that when a wrong signal is outputted due to internal mixed contact or disconnection during manufacture of an LSI or due to internal mixed contact or disconnection during use or a brake command signal which is a main point of speed control is not outputted, a serious accident is caused.

[0014] It is necessary that an LSI corresponding to future various controls constitutes a control circuit which satisfies the functions corresponding to those controls, improves the self check function for detecting a failure of the LSI itself, and satisfies the fail safe control for controlling on the safety side when an error occurs.

[0015] Preferably, therefore, an object of the present invention is to provide a control circuit which improves the self check function for detecting a failure of a controller and has the fail safe function for controlling on the safety side when an error occurs and a controller and a system using it.

[0016] Aspects of the present invention are set out in the appended claims.

[0017] Preferably, the present invention comprises a command speed frequency conversion means for converting an ATP command speed signal to a frequency,

a first data conversion means for converting an output signal of the command speed frequency conversion means to digital data,

a speed frequency conversion means for converting an actual speed of an electric motor vehicle to a frequency,

a second data conversion means for converting an output signal of the speed frequency conversion means to digital data,

a brake command output means for outputting a brake command signal according to the deviation between the output data of the first data conversion means and the output data of the second data conversion means,

a means for duplicating the brake command output means to a system A and a system B inside an LSI,

a means for inputting the first data corresponding to an ATC command speed signal and the second data corresponding to an actual speed of an electric motor vehicle to the circuits of the system A and the

system B of the duplicated LSI at the same time;

a means for generating first control data in which CRC data when a generation polynomial expression is assumed as G0 (X) is added on the basis of the first data and second control data in which CRC data when a generation polynomial expression is assumed as G1 (X) is added, a switching means for selecting one of the first control data and the second control data,

a means for checking an error of an output signal of the switching means by using the first failure detector corresponding to the generation polynomial expression G0 (X) which is connected in parallel and the second failure detector corresponding to the generation polynomial expression G1 (X);

a comparison means for comparing an output of the first failure detector of the system A and an output of the second failure detector, a comparison means for comparing an output of the first failure detector of the system B and an output of the second failure detector,

a means for controlling the switching means of the system B by an output signal of the comparison means of the system A and selecting the first control data or the second control data;

a sign inversion means for inverting the sign of an output signal of the comparison means of the system B, and;

a means for controlling the switching means of the system A by an output signal of the sign inversion means of the system B and selecting the first control data or the second control data.

[0018] Preferably, furthermore, the present invention comprises a means for arranging and wiring the system A and the system B of the duplicated circuit away from each other and a means for widening the arrangement interval of an output signal of the comparison means of the system A and an output signal of the comparison means of the system B and the conductor interval.

[0019] The first control data of the system A and the system B are decided as normal by the first failure detector and output signals thereof are L, whereas they are decided as abnormal by the second failure detector and output signals thereof are H. The second control data are decided as abnormal by the first failure detector and output signals thereof are H, whereas they are decided as normal by the second failure detector and output signals thereof are L.

[0020] At the start time of operation, the first control data is selected in the system A and the second control data is selected in the system B.

[0021] Therefore, the first control data of the system A is checked by the first failure detector and the second failure detector, and the output signal L of the first failure detector and the output signal H of the second failure detector are compared by the comparison means of the system A, and;

the switching means of the system B is controlled by a comparison output signal H obtained under this condition, and the second control data is switched to the first control data.

[0022] When the second control data is switched to the first control data, the output signal L of the first failure detector and the output signal H of the second failure detector are compared by the comparison means of the system B, and a comparison output signal H obtained under this condition is inverted in sign by the sign inversion means and goes L, and;

the switching means of the system A is controlled, and the first control data is switched to the second control data.

[0023] When the first control data is switched to the second control data, the output signal H of the first failure detector and the output signal L of the second failure detector are compared by the comparison means of the system A, and;

the switching means of the system B is controlled by a comparison output signal L obtained under this condition, and the first control data is switched to the second control data.

[0024] When the first control data is switched to the second control data, the output signal H of the first failure detector and the output signal L of the second failure detector are compared by the comparison means of the system B, and a comparison output signal L obtained under this condition is inverted in sign by the sign inversion means and goes H, and;

the switching means of the system A is controlled, and the second control data is switched to the first control data.

When the second control data is switched to the first control data, the output signal L of the first failure detector and the output signal H of the second failure detector are compared by the comparison means of the system A, and;

the switching means of the system B is controlled by a comparison output signal H obtained under this condition, and the second control data is switched to the first control data.

When the second control data is switched to the first control data, the output signal L of the first failure detector and the output signal H of the second failure detector are compared by the comparison means of the system B, and a comparison output signal H obtained under this condition is inverted in sign by the sign inversion means and goes L, and;

the switching means of the system A is controlled, and the second control data is switched to the first control data.

[0025] As mentioned above, by a signal obtained by an operation of the own system, the switching means of the opposite system is controlled. Therefore, when the control data, the failure detector, the comparison means, and the switching means are normal, output signals of the switching means of the system A and the

system B are alternated in a fixed period. However, when one of them breaks down, alternating signals of the switching means of the system A and the system B are stopped.

[0026] The alternation of alternating signals of the switching means is monitored.

[0027] When the system A and the system B of the duplicated circuit are arranged and wired away from each other and the arrangement interval of another comparison means for comparing an output signal of the comparison means of the system A and an output signal of the comparison means of the system B and the conductor interval are widened, it can be prevented that for example, a failure of the system A affects the system B, and they operate as if they are normal, and a brake command signal to be outputted is not outputted, and a brake command signal which is not required to be outputted is outputted.

[0028] Other objects and aspects of the invention will become apparent from the following description of embodiments with reference to the accompanying drawings in which:

Fig. 1 is a drawing showing an embodiment of the present invention;
Fig. 2 is a drawing showing an embodiment of the controller of the present invention;
Fig. 3 is a data configuration diagram;
Fig. 4 is a conceptual diagram of a frequency comparison operation;
Fig. 5 shows the number of operations and failure signal waveforms;
Fig. 6 is a drawing showing a frequency matcher;
Fig. 7 is a timing chart of the frequency matcher;
Fig. 8 is a drawing showing another embodiment of the present invention;
Fig. 9 is a data configuration diagram of each memory;
Fig. 10 is an illustration for failure detection signals and a memory switching operation;
Fig. 11 is a drawing showing a frequency converter;
Fig. 12 is an illustration for a frequency conversion operation;
Fig. 13 is a drawing showing a frequency comparator;
Fig. 14 is a timing chart of a frequency comparison operation;
Fig. 15 is an illustration for a multi-frequency comparison operation;
Fig. 16 is a drawing showing another embodiment of the present invention;
Fig. 17 is a drawing showing another embodiment of the present invention;
Fig. 18 is a drawing showing another embodiment of the present invention;
Fig. 19 is an illustration for the LSI layout of the present invention;
Fig. 20 is a drawing showing another embodiment of the present invention;
Fig. 21 is a drawing showing another embodiment of the present invention;
Fig. 22 is a drawing showing another embodiment of the present invention;
Fig. 23 is a drawing showing another embodiment of the present invention;
Fig. 24 is a drawing showing another embodiment of the present invention; and
Fig. 25 is a drawing showing an example of programming in the present invention;

[0029] A case that the present invention is applied to an automatic train controller ATP will be explained hereunder.

[0030] The ATP gives braking force to a train according to the deviation between an ATP command speed signal sent from the ground and the running speed of the train (hereinafter referred to as an electric motor vehicle) at that time and controls the running speed of the electric motor vehicle to less than the command speed.

[0031] Fig. 1 is a block diagram of an ATP system using the present invention.

[0032] In Fig. 1, numeral 1 indicates a rail on which an electric motor vehicle runs, 23 a body of the electric motor vehicle, 2 a wheel of the electric motor vehicle, 3 a speed generator attached to the shaft of the wheel 2 for detecting the speed of the speed generator, 4 a waveform shaper (or a signal converter) for shaping the waveform of an output voltage from the speed generator 3 and outputting a speed frequency signal 5 in proportion to the speed of the electric motor vehicle, 6 an antenna for receiving a frequency-modulated ATP command speed signal from the ground, 7 a car receiver for demodulating the frequency-modulated ATP command speed signal received by the antenna 6 and then shaping and amplifying the waveform, 8 an ATP command speed signal which is an output signal of the car receiver 7, 9 an ATP device for controlling the speed of the electric motor vehicle from the ATP command speed signal and an actual speed of the electric motor vehicle, and 22 a braking device for receiving a brake command signal 21 from the ATP device and giving actual braking force to the electric motor vehicle.

[0033] By using this constitution, the speed of the electric motor vehicle is controlled so as to eliminate the deviation between the ATP command speed and the actual speed of the electric motor vehicle or to prevent the actual speed of the electric motor vehicle from exceeding the ATP command speed.

[0034] The fail safe technology of the controller of the aforementioned ATP device will be explained hereunder by referring to Fig. 2.

[0035] Numeral 1800 indicates a controller, 1810 a first processor for inputting and processing first input data and outputting first output data 1860 and a first detection signal 1880, 1820 a second processor for inputting and processing second input data and outputting

second output data 1870 and a second detection signal 1890 which is inverted in sign, 1830 a signal inverter for inverting the detection signal processed by the second processor, 1900 a first transmitter for transmitting the first detection signal 1880 outputted from the first processor 1810 to the second processor 1820, and 1910 a second transmitter for transmitting the second detection signal 1890 outputted from the second processor via the signal inverter 1830 to the first processor 1810.

[0036] The first input data and the second input data are data which are generated and given by a microcomputer or read from a memory.

[0037] As to the first input data, there are cases that it has data for processing first output data and check data for checking the above data and that it has no check data, and check data is generated by processing of the first processor, and a first detection signal is generated.

[0038] As to the second input data, there are cases that the content of the data is the same as that of the first input data and that the content is different from that of the first input data.

[0039] As to the second input data, there are cases that it has check data in the same way as with the aforementioned first input data and that it has no check data. When the second input data has no check data, there are cases that check data is generated by the second processor in the same way as with the aforementioned first input data and that no check data is generated even by the second processor.

[0040] Furthermore, in this embodiment, the first input data and the second input data are independent of each other. However, one input data can be easily inputted to two processors.

[0041] The first processor and the second processor process the first or second input data which is sequentially inputted by a serial processing type ring processor or fetch both data in a microcomputer in parallel and perform parallel processing.

[0042] The first and second detection signals indicate whether the first processor and the second processor operate normally or abnormally. When alternating signals in the predetermined period are outputted, the detection signals indicate that the processors operate normally.

[0043] These detection signals can be used also as a detection signal for indicating whether the check results of the contents of input data are correct or wrong.

[0044] Another device is controlled by the first output data and the second output data.

[0045] Before outputting to another device, by an output portion for detecting a match in the first output data and the second output data or outputting final output data using the first or second detection signal, another device to be controlled is controlled.

[0046] The processing of the controller having the aforementioned constitution is as follows:

[0047] The first example of the processing is a case of outputting the first detection signal first and generating alternating signals by repeating inversion of this signal.

[0048] The first input data is inputted and processed by the first processor and the first output data and the first detection signal are outputted. The first detection signal is inputted to the second processor and processed together with the second input data and the second output data and the second detection signal are generated and outputted.

[0049] The second detection signal is inverted in sign by the signal inverter and inputted to the first processor. When the first detection signal processed by the first processor is a high (hereinafter referred to as H) level signal, the second detection signal processed by the second processor also becomes an H-level signal and when the first detection signal of the first processor is a low (hereinafter referred to as L) level signal, the second detection signal processed by the second processor also becomes an L level signal.

[0050] The second detection signal of H level is inverted in sign by the signal inverter and the detection signal of L level is inputted to the first processor.

[0051] Therefore, when the first detection signal processed by the first processor is an L-level signal, the L-level signal is inputted to the second processor and the detection signal of the second processor becomes an L-level signal. However, since the signal is inverted in sign by the signal inverter, the second detection signal of H level is inputted to the first processor and when the first processor and the second processor operate normally, the first and second detection signals become signals alternating to the H, L, H, --- levels.

[0052] The aforementioned processing of the detection signal in the first or second processor is output of a signal having the same level as the inputted level. Namely, when the first detection signal of H or L level is outputted from the first processor first, the first and second detection signals become alternating signals thereafter as long as the first and second processors operate normally.

[0053] The second example of the processing is a case of implementing logic between the first detection signal outputted from the first processor and the check data of the second input data (or the check data generated from the second input data) and outputting a detection signal from the second processor.

[0054] By doing this, the present invention not only detects whether the first or second processor operates normally or abnormally but also can check whether the first or second input data is normal or abnormal.

[0055] Namely, when the first detection signal does not match the check data of the second input data, a signal of a different level from that of the first detection signal is outputted from the second processor as a detection signal. By doing this, the second detection signal via the signal inverter becomes a signal of the same level as that of the first detection signal, so that no alternating signal is outputted.

[0056] The same may be said with the second detection signal of the first processor and the check data of the first input data. In the case of this processing, a constitution having a logic unit for implementing logic in the processor is used.

[0057] Next, the constitution of the ATP device 9 shown in Fig. 1 which has the aforementioned characteristics of the controller in the automatic train control system will be explained.

[0058] The ATP device 9 comprises a first microcomputer 10 for converting the ATP command speed signal 8 to control data 12 of the first microcomputer, a second microcomputer 11 for converting the ATP command speed signal 8 to control data 13 of the second microcomputer by performing the same process as that for the first microcomputer, a logic circuit 15 of the system A for implementing logic between the control data 12 of the first microcomputer 10 and a speed frequency signal 5 and outputting an A system logic output signal 17, a logic circuit 16 of the system B for implementing logic between the control data 13 of the second microcomputer 11 and the speed frequency signal 5 and outputting a B system logic output signal 18, and a controller 14 having a duplicated logic constitution of a logic circuit 15 of the system A and a logic circuit 16 of the system B.

[0059] The logic circuit 15 of the system A comprises a frequency converter 150 for converting the control data 12 of the first microcomputer to an ATP command speed frequency (signal) 151, a second transmitter for transmitting an ATP command speed frequency signal 2150 to a third processor 2030, a third transmitter 2200 for transmitting a third detection signal 2160 to a fourth processor 2040, and a fourth transmitter 2210 for transmitting a fourth detection signal 2170 outputted from the fourth processor 2040 via a sign inverter 2050 to a first processor 2010.

[0060] First input data 2060, second input data 2070, third input data 2080, and fourth input data 2090 are data which are generated and given by the microcomputer or read from the memory.

[0061] As to the first input data 2060, there are cases that it has data for processing first output data 2100 and check data for checking the above data and that it has no check data, and check data is generated by processing of the first processor 2010, and a first detection signal 2140 is generated.

[0062] Also as to the second input data 2070, there are cases that it has data for processing second output data 2110 and check data for checking the above data and that it has no check data, and check data is generated by processing of the second processor 2020, and the second detection signal 2150 is generated.

[0063] Also as to the third input data 2080, there are cases that it has data for processing third output data 2120 and check data for checking the above data and that it has no check data, and check data is generated by processing of the third processor 2030, and the third detection signal 2160 is generated.

[0064] Also as to the fourth input data 2090, there are cases that it has data for processing fourth output data 2130 and check data for checking the above data and that it has no check data, and check data is generated by processing of the fourth processor 2040, and the fourth detection signal 2170 is generated.

[0065] The first processor 2010 processes the first input data 2060 which is sequentially inputted by a dedicated serial processing type ring processor or fetches the data in the microcomputer in parallel and performs parallel processing.

[0066] The second processor 2020 also processes the second input data 2070 which is sequentially inputted by a dedicated serial processing type ring processor or fetches the data in the microcomputer in parallel and performs parallel processing.

[0067] The third processor 2030 also processes the third input data 2080 which is sequentially inputted by a dedicated serial processing type ring processor or fetches the data in the microcomputer in parallel and performs parallel processing.

[0068] The fourth processor 2040 also processes the fourth input data 2090 which is sequentially inputted by a dedicated serial processing type ring processor or fetches the data in the microcomputer in parallel and performs parallel processing.

[0069] The first detection signal 2140 indicates whether the first processor 2010 operates normally or abnormally, and the second detection signal 2150 indicates whether the second processor 2020 operates normally or abnormally, and the third detection signal 2160 indicates whether the third processor 2030 operates normally or abnormally, and the fourth detection signal 2170 indicates whether the fourth processor 2040 operates normally or abnormally, and they are alternating signals which alternate in the predetermined period respectively.

[0070] These detection signals can be used also as a signal for indicating whether the check results of the contents of input data are correct or wrong.

[0071] Namely, the first processor 2010 outputs the processing result for checking the content of the input data 2060 as the detection signal 2140, and the second processor 2020 outputs the processing result for checking the content of the input data 2070 as the detection signal 2150, and the third processor 2030 outputs the processing result for checking the content of the input data 2080 as the detection signal 2160, and the fourth processor 2040 outputs the processing result for checking the content of the input data 2090 as the detection signal 2170.

[0072] The output data 2100 of the first processor 2010, the output data 2110 of the second processor 2020, the output data 2120 of the third processor 2030, and the output data 2130 of the fourth processor 2040 are outputted to another device so as to control it.

[0073] Before outputting to another device, by an output portion, for example, for detecting a match in the first

output data 2100, the second output data 2110, the third output data 2120, and the fourth output data 2130, detecting a match in the first output data 2100 and the second output data 2110, detecting a match in the third output data 2120 and the fourth output data 2130, or furthermore outputting final output data using the first detection signal 2140, the second detection signal 2150, the third detection signal 2160, and the fourth detection signal 2170, another device to be controlled is controlled.

[0074] The processing of a controller 2000 having the aforementioned constitution is as follows:

[0075] The first input data 2060 is inputted to the first processor 2010, and the second input data 2070 is inputted to the second processor 2020, and the third input data 2080 is inputted to the third processor 2030, and the fourth input data 2090 is inputted to the fourth processor 2040, and operations are executed respectively.

[0076] The first output data 2100 and the first detection signal 2140 are outputted from the first processor 2010.

[0077] The first detection signal 2140 is inputted to the second processor 2020 and processed together with the second input data 2070 and the second output data 2110 and the second detection signal 2150 are generated, and the second detection signal 2150 is inputted to the third processor 2030 and processed together with the third input data 2080 and the third output data 2120 and the third detection signal 2160 are generated, and the third detection signal 2160 is inputted to the fourth processor 2040 and processed together with the fourth input data 2090 and the fourth output data 2130 and the fourth detection signal 2170 are generated, and the fourth detection signal 2170 is inverted in sign by the sign inverter 2050 and inputted to the first processor 2010.

[0078] When the first detection signal 2140 of by the first processor 2010 is an H-level signal, the second detection signal 2150 of the second processor 2020 also becomes an H-level signal and when the first detection signal 2140 is a L level signal, the second detection signal 2150 of the second processor 2020 also becomes an L level signal.

[0079] The outputs of the detection signals of all the processors are assumed as L level first. Therefore, the sign inversion signal 2210 of the fourth detection signal 2140 of the fourth processor 2040 becomes an H-level signal and is inputted to the first processor 2010.

[0080] As a result, when processed by the first processor 2010, the output level of the first detection signal2140 becomes H, and when processed by the second processor 2020 next, the output level of the second detection signal 2150 becomes H, and when processed by the third processor 2030 next, the output level of the third detection signal 2160 becomes H, and when processed by the fourth processor 2040 finally, the output level of the fourth detection signal 2170 becomes H.

[0081] Since the sign of the output of the fourth detection signal 2170 is inverted by the sign inverter 2050, the output level of the sign inversion signal 2210 is changed from H to L.

[0082] Therefore, the output level of the first detection signal 2140 of the first processor 2010 is changed from H to L, and the output level of the second detection signal 2150 of the second processor 2020 is changed from H to L, and the output level of the third detection signal 2160 of the third processor 2030 is changed from H to L next, and the output level of the fourth detection signal 2170 of the fourth processor 2040 is changed from H to L finally.

[0083] Since the sign of the output of the fourth detection signal 2170 is inverted by the sign inverter 2050, the output level of the sign inversion signal 2210 is changed from H to L and returned to the initial state.

[0084] Since the detection signals are connected in a loop from the first processor to the fourth processor as mentioned above, the first input data to the fourth input data and the first processor to the fourth processor are all normal. When they operate correctly, the first detection signal 2140 to the fourth detection signal 2170 become alternating signals which alternate in a fixed period and when one of the processors breaks down and the corresponding detection signal is fixed to H or L, the alternation of the detection signals constituting the loop is stopped.

[0085] Therefore, it is desirable to monitor a failure detection signal of the loop and take an emergency action at the time of alternation stop. If all the failure detection signals are monitored, a broken-down processor can be known and the failure can be analyzed more briefly.

[0086] In Fig. 20, an embodiment having four processors is explained. However, even if processors in an optional number are provided, it is desirable to connect a failure detection signal in the same way and there are no restrictions on the number of processors.

[0087] Fig. 21 is a drawing showing another embodiment of the present invention. Fig. 21 is a drawing of an embodiment in which the processors are shared, and the input portions comprise a time division operation type parallel-serial converter, and the output portions comprise a time division operation type serial-parallel converter.

[0088] A controller 3000 comprises a first control circuit 3010 including a time division operation type parallel-serial converter 3020, a first processor 3030, and a time division operation type serial-parallel converter 3040 and a second control circuit 3200 including a time division operation type parallel-serial converter 3210, a second processor 3220, and a time division operation type serial-parallel converter 3230. A failure detection signal 3130 of the first control circuit 3010 is inputted to the parallel-serial converter 3210 of the second control unit 3200, and a failure detection signal 3320 of the second control circuit 3200 is inverted in sign by a sign inverter 3330, and a sign inversion signal 3340 is inputted to the parallel-serial converter 3020 of the first control

unit 3010.

[0089] First input data 3050, second input data 3060, and third input data 3070 are inputted to the parallel-serial converter 3020 of the first control circuit 3010 and fourth input data 3240, fifth input data 3250, and sixth input data 3260 are inputted to the parallel-serial converter 3210 of the second control circuit 3200.

[0090] It is assumed that the output levels of the failure detection signal 3130 of the first control circuit 3010 and the failure detection signal 3320 of the second control circuit 3130 are L first.

[0091] The first input data 3050 is converted to a serial signal 3080 by the parallel-serial converter 3020 of the first control circuit 3010, processed by the first processor 3030, outputted as a serial output signal 3090, converted to a parallel signal by the serial-parallel converter 3040, and then outputted as an output signal 3100.

[0092] On the other hand, the fourth input data 3240 is converted to a serial signal 3270 by the parallel-serial converter 3210 of the second control circuit 3200, processed by the second processor 3220, outputted as a serial output signal 3280, converted to a parallel signal by the serial-parallel converter 3230, and then outputted as an output signal 3290.

[0093] In the same way, the second input data 3060 inputted to the first control circuit 3010 is processed by the first processor 3030 and outputted as an output signal 3110, and the fifth input data 3250 inputted to the second control circuit 3200 is processed by the second processor 3220 and outputted as an output signal 3300, and the third input data 3070 inputted to the first control circuit 3010 is processed by the first processor 3030 and outputted as an output signal 3120, and the sixth input data 3260 inputted to the second control circuit 3200 is processed by the second processor 3220 and outputted as an output signal 3310.

[0094] Next, when the failure detection signal 3320 of the second control circuit 3200 is inverted in sign by the sign inverter 3330 and the sign inversion signal 3340 of H level is inputted to the parallel-serial converter 3020 of the first control circuit 3010, the failure detection signal 3130 of H level is outputted by the same operation as that mentioned above.

[0095] Since the failure detection signal 3130 of H level of the first control circuit 3010 is inputted to the parallel-serial converter 3210 of the second control circuit 3200, the failure detection signal 3320 of H level is outputted by the same operation as that mentioned above.

[0096] Since this failure detection signal 3320 of H level is inverted in sign by the sign inverter 3330 and the failure detection signal of L level is inputted to the parallel-serial converter 3020 of the first control circuit 3010, the failure detection signal 3130 of H level is outputted by the same operation as that mentioned above.

[0097] Therefore, when the first control circuit 3010 and input data and the second control circuit 3200 and input data are normal, the failure detection signal 3130 of the first control circuit 3010 and the failure detection signal 3320 of the second control circuit 3200 become alternating signals which alternate in a fixed period.

[0098] In Fig. 21, the first processor 3020 and the second processor 3210 may use a microcomputer. In this case, various ways can be selected by a program. For example, by a method for executing the failure detection process after the input data process or executing the input data process and the failure detection process in parallel, the same operation as that mentioned above can be realized.

[0099] Needless to say, by replacing the parallel-serial converter with a multiplexer and the serial-parallel converter with a demultiplexer, the same operation can be realized.

[0100] Fig. 22 is a drawing showing another embodiment of the present invention. It is a difference that in the embodiment shown in Fig. 22, the sign inverter 2050 in the embodiment shown in Fig. 20 is a 1-bit adder 2220. The others are all the same, so that the explanation of the operations thereof is omitted and the operation of the adder 2220 shown in Fig. 22 will be explained hereunder.

[0101] It is assumed that the first processor 2010, the second processor 2020, the third processor 2030, and the fourth processor 2040 constituting the controller 2000 are normal and the output levels of the first detection signal 2140, the second detection signal 2150, the third detection signal 2160, and the fourth detection signal 2170 are L.

[0102] The first input data 2060 is inputted and processed by the first processor 2010 and outputted as the first detection signal 2140 of L level. This first detection signal 2140 is inputted to the second processor 2020, processed together with the second input data 2070, and outputted as the second detection signal 2150 of L level. This second detection signal 2150 is inputted to the third processor 2030, processed together with the third input data 2080, and outputted as the third detection signal 2160 of L level. This third detection signal 2160 is inputted to the fourth processor 2040, processed together with the fourth input data 2090, and outputted as the fourth detection signal 2170 of L level.

[0103] This fourth detection signal 2170 is inputted to the adder 2220 and added to H-level data, so that the output level of an output signal 2210 thereof becomes H and the signal is inputted to the first processor 2010.

[0104] Since this H-level output signal 2210 is processed together with the first input data 2060, the first detection signal 2140 becomes an H-level signal and hereafter by the same operation, the second detection signal 2150 of the second processor 2020 becomes an H-level signal, and the third detection signal 2160 of the third processor 2030 becomes an H-level signal, and the fourth detection signal 2170 of the fourth processor 2040 becomes an H-level signal.

[0105] When this fourth detection signal 2170 is inputted to the adder 2220 and added to H-level data, the output level of the output signal 2210 thereof becomes

L. This output signal 2210 is inputted to the first processor 2010 and processed together with the first input data. Namely, it is returned to the initial state.

[0106] Therefore, when each unit of the controller 2000 is normal, the first detection signal 2140, the second detection signal 2150, the third detection signal 2160, and the fourth detection signal 2170 constituting a loop become alternating signals which alternate to the H or L level in a fixed period, so that it is desirable to present a constitution that one of the signals is monitored and when the alternation is stopped, emergency control is executed.

[0107] In Fig. 22, an example of four processors is explained as in Fig. 20. However, even if processors in an optional number are provided, it is desirable to connect them in the same way and there are no restrictions on the number of processors.

[0108] Fig. 23 is a drawing showing another embodiment of the present invention. It is a difference from Fig. 20 that in the embodiment shown in Fig. 23, 2-bit data of "0" "1" (indicating 1 in decimal) is added to a 2-bit detection signal of a processor and the addition output signal is inputted to the next processor and processed together with a signal inputted to the processor.

[0109] In Fig. 23, the first processor 2010, the second processor 2020, the third processor 2030, and the fourth processor 2040 and the first adder 2220, the second adder 2230, the third adder 2240, and the first subtracter 2250 are normal respectively, and the output of the first detection signal 2140 indicating a status 2 bits long is "0" "0" (indicating 0 in decimal), and the output of the second detection signal 2150 is also "0" "0", and the output of the third detection signal 2160 is also "0" "0", and the output of the fourth detection signal 2170 is also "0" "0".

[0110] Since the first input data 2060 is inputted and processed by the first processor, the first output data 2100 and "0" "0" of the first detection signal 2140 are outputted.

[0111] Since the output "0" "0" of the first detection signal 2140 is added to 2-bit data of "0" "1" (indicating 1 in decimal) by the first adder 2220, the addition output 2260 becomes "0" "1".

[0112] Since "0" "1" of the addition output 2260 is inputted to the second processor 2020 and processed together with the second input data 2070, the second output data 2110 and "0" "1" of the second detection signal 2150 are outputted.

[0113] Since the output "0" "1" of the second detection signal 2150 is added to data of "0" "1" by the second adder 2230, the addition output 2270 becomes "1" "0" (indicating 2 in decimal).

[0114] Since "1" "0" of the addition output 2270 is inputted to the third processor 2030 and processed together with the third input data 2080, the third output data 2120 and "1" "0" of the third detection signal 2160 are outputted.

[0115] Since the output "1" "0" of the third detection signal 2160 is added to data of "0" "1" by the third adder 2240, the addition output 2280 becomes "1" "1" (indicating 3 in decimal).

[0116] Since "1" "1" of the addition output 2280 is inputted to the fourth processor 2040 and processed together with the fourth input data 2090, the fourth output data 2130 and "1" "1" of the fourth detection signal 2170 are outputted.

[0117] Since "1" "1" of the fourth detection signal 2170 is inputted to the first subtracter 2250 and data of "1" "0" (indicating 2 in decimal) is subtracted from data of "1" "1", the subtraction output 2290 becomes "0" "1".

[0118] Since "0" "1" of the subtraction output 2290 is inputted to the first processor 2010 and processed together with the first input data 2090, the first output data 2100 and "0" "1" of the first detection signal 2140 are outputted.

[0119] Since "0" "1" of the first detection signal 2140 is added to data of "0" "1" by the first adder 2220, the addition output 2260 becomes "1" "0" (indicating 2 in decimal).

[0120] Since "1" "0" of the addition output 2260 is inputted to the second processor 2020 and processed together with the second input data 2070, the second output data 2110 and "1" "0" of the second detection signal 2150 are outputted.

[0121] Since "1" "0" of the second detection signal 2150 is added to data of "0" "1" by the second adder 2230, the addition output 2270 becomes "1" "1" (indicating 3 in decimal).

[0122] Since "1" "1" of the addition output 2270 is inputted to the third proce sor 2030 and processed together with the third input data 2080, the third output data 2120 and "1" "1" of the third detection signal 2160 are outputted.

[0123] Since "1" "1" of the third detection signal 2160 is added to data of "0" "1" by the third adder 2240, the addition output 2280 becomes "0" "0" (indicating 0 in decimal).

[0124] Since "0" "0" of the addition output 2280 is inputted to the fourth processor 2040 and processed together with the fourth input data 2090, the fourth output data 2130 and "0" "0" of the fourth detection signal 2170 are outputted.

[0125] Since "0" "0" of the fourth detection signal 2170 is inputted to the first subtracter 2250 and data of "1" "0" is subtracted, the subtraction output 2290 becomes "1" "0" (indicating 2 in decimal).

[0126] Since "1" "0" of the subtraction output 2290 is inputted to the first processor 2010 and processed together with the first input data 2090, the first output data 2100 and "1" "0" of the first detection signal 2140 are outputted.

[0127] Since "1" "0" of the first detection signal 2140 is added to data of "0" "1" by the first adder 2220, the addition output 2260 becomes "1" "1" (indicating 3 in decimal).

[0128] Since "1" "1" of the addition output 2260 is in-

putted to the second processor 2020 and processed together with the second input data 2070, the second output data 2110 and "1" "1" of the second detection signal 2150 are outputted.

[0129] Since "1" "1" of the second detection signal 2150 is added to data of "0" "1" by the second adder 2230, the addition output 2270 becomes "0" "0" (indicating 3 in decimal).

[0130] Since "0" "0" of the addition output 2270 is inputted to the third processor 2030 and processed together with the third input data 2080, the third output data 2120 and "0" "0" of the third detection signal 2160 are outputted.

[0131] Since "0" "0" of the third detection signal 2160 is added to data of "0" "1" by the third adder 2240, the addition output 2280 becomes "0" "1" (indicating 1 in decimal).

[0132] Since "0" "1" of the addition output 2280 is inputted to the fourth processor 2040 and processed together with the fourth input data 2090, the fourth output data 2130 and "0" "1" of the fourth detection signal 2170 are outputted.

[0133] Since "0" "1" of the fourth detection signal 2170 is inputted to the first subtracter 2250 and data of "1" "0" is subtracted, the subtraction output 2290 becomes "0" "0" (indicating 0 in decimal).

[0134] Since "0" "0" of the subtraction output 2290 is inputted to the first processor 2010 and processed together with the first input data 2090, the first output data 2100 and "0" "0" of the first detection signal 2140 are outputted.

[0135] When the controller 2000 is structured so that "0" "1" (1 in decimal) is added to an output signal of the first failure detection signal of the first processor and the addition signal is inputted to the second processor, and "0" "1" (1 in decimal) is added to an output signal of the second failure detection signal and the addition signal is inputted to the third processor, and "0" "1" (1 in decimal) is added to an output signal of the third failure detection signal and the addition signal is inputted to the fourth processor, and "1" "0" (2 in decimal) is subtracted from an output signal of the fourth failure detection signal and the subtraction signal is inputted to the first processor, the failure detection signals of the processors become alternating signals which alternate in a fixed period when the units of the controller 2000 are normal.

[0136] In Fig. 23, an example of four processors is explained as in Fig. 22. However, even if processors in an optional number are provided, it is desirable to connect them in the same way and there are no restrictions on the number of processors.

[0137] Fig. 24 shows another embodiment of the present invention . Fig. 24 is different from Fig. 21 in the processing method for the second detection signal.

[0138] Namely, when the first input data 3050 is all inputted to the first control circuit 3010 in Fig. 24, the second input data 3060 is inputted next, and when the second input data 3060 is all inputted, the third input data 3070 is inputted next, and when the third input data 3070 is all inputted, CRC data 3140 for checking data is inputted next as a failure detection signal 3160 via a first adder 3150.

[0139] These data are converted sequentially to a serial signal 3080 by the parallel - serial converter 3020, inputted to the first processor 3030, processed as predetermined, and outputted as a serial signal 3090. This serial signal 3090 is converted to and outputted as an output signal 3100, an output signal 3110, and an output signal 3120 which are parallel with each other by the serial - parallel converter 3040, so that another device is controlled and furthermore the failure detection signal 3130 is outputted and inputted to the second adder 3340.

[0140] When the fourth input data 3240 is all inputted to the second control circuit 3200 in the same way, the fifth input data 3250 is inputted next, and when the fifth input data 3250 is all inputted, the sixth input data 3260 is inputted next, and when the sixth input data 3260 is all inputted, CRC data 3330 for checking data is inputted next as a failure detection signal 3350 via the second adder 3340.

[0141] These data are converted sequentially to a serial signal 3270 by the parallel - serial converter 3210, inputted to the second processor 3220, processed as predetermined, and outputted as a serial signal 3280. This serial signal 3280 is converted to and outputted as an output signal 3290, an output signal 3300, and an output signal 3310 which are parallel with each other by the serial - parallel converter 3230, so that another device is controlled, and furthermore the failure detection signal 3320 is outputted and inverted in sign by the sign inverter 3350, and a sign inversion failure detection signal 3360 is inputted to the first adder 3150.

[0142] In the initial state, it is assumed that the output levels of the detection failure signal 3130 of the first control circuit 3010 and the detection failure signal 3320 of the second control circuit 3200 are L.

[0143] The L-level detection failure signal 3130 of the first control circuit 3010 is inputted to the second adder 3340 of the second control circuit 3200 but the CRC data 3330 will not be destroyed. In other words, the normal CRC data 3350 is inputted to the second serial - parallel converter 3210.

[0144] On the other hand, the output level of a sign inversion signal 3370 of the detection failure signal 3320 of the second control circuit 3200 is H. The H-level sign inversion signal 3370 is inputted to the first adder 3150 and destroys the CRC data 3140.

[0145] This destroyed CRC data 3160 is inputted to the first parallel-serial converter 3020, so that it is processed by the first processor 3030 and the H-level failure detection signal 3130 is outputted via the first serial-parallel converter 3040.

[0146] This H-level failure detection signal 3130 is inputted to the second adder 3340, so that the CRC data 3330 is destroyed.

[0147] This destroyed CRC data 3350 is inputted to the second parallel-serial converter 3210, so that it is processed by the second processor 3220 and the H-level failure detection signal 3320 is outputted via the second serial-parallel converter 3230.

[0148] This H-level failure detection signal 3130 is inverted in sign by the sign inverter 3360 and an L-level signal is inputted to the first adder 3150.

[0149] Namely, since the CRC data 3140 is not destroyed by the first processor 3150, the normal CRC data is inputted to the first parallel-serial converter. Namely, it is returned to the initial state and controlled.

[0150] As mentioned above, when all the units of the controller 3000 are normal, the failure detection signal 3130 and the failure detection signal 3320 are alternated in a fixed period.

[0151] Fig. 25 is an example of a program when the first processor and the second processor shown in Figs. 21 and 24 comprise a microcomputer respectively. The data processing is executed after the input process is executed and the output process is executed according to the result. When this process ends, the diagnosis process for detecting a failure starts. Namely, the failure diagnosis process is executed after the input process for detecting a failure is executed and when this process ends, the output process is executed. Namely, when it is normal, no signal is outputted. However, when it is abnormal, a signal is outputted and for example, an emergency process is executed.

[Effects of the Invention]

[0152] As mentioned above, according to the present invention, a normal operation and an abnormal operation of a controller comprising a plurality of processors or logic units can be detected certainly.

[0153] The content of input data processed by each processor can be checked, so that not only a normal operation and an abnormal operation of the hardware but also a normal operation and an abnormal operation of the software can be detected.

[0154] When the present invention is applied to an ATP device, control data for the two systems are generated from an ATP command speed signal, and each logic unit in the ATP device is duplicated so as to process each control data, and each system has at least two CRC data for checking the control data. By changing the opposite CRC data of each logic unit or selecting one of the two according to the content of a failure detection signal from each duplicated logic unit, checking of the control data and checking of the operation of each logic circuit can be realized.

[0155] The ATP device comprises a frequency comparator 152 for comparing the ATP command speed frequency 151 and the speed frequency 5 and a failure detector 153 for checking the content of the control data 12 of the first microcomputer and the status of the logic circuit 15 on the basis of a failure detection signal from the system B and outputting an A system failure detection signal 154.

[0156] The logic circuit 16 of the system B comprises a frequency converter 160 for converting the control data 13 of the second microcomputer to an ATP command speed frequency (signal) 161, a frequency comparator 162 for comparing the ATP command speed frequency 151 and the speed frequency 5, and the failure detector 153 for checking the content of the control data 13 of the second microcomputer and the status of the logic circuit 16 on the basis of a failure detection signal from the system A and outputting a B system failure detection signal 164.

[0157] Numeral 19 indicates a logic circuit for generating a sign inversion signal 165 for inverting the sign of the B system failure detection signal 164 and inputting it to the failure detector 153 of the system A. For example, it is an inverter circuit. This sign inversion logic circuit 19 is connected between the output side of the failure detector 153 of the system A and the input side of the failure detector 163 of the system B. However, the sign of the failure detection signal 154 of the system A may be inverted.

[0158] The ATP command speed is a limit speed which is preset according to the trajectory condition and others and flows through the rail 1 as a frequency-modulated signal.

[0159] This ATP command speed is received by the receiving antenna 6 of a running electric motor vehicle and demodulated, amplified, and shaped at the same time by the car receiver 7, and then detected.

[0160] The speed frequency 5 in proportion to the speed of an electric motor vehicle is detected by shaping the output voltage of the speed generator 3 directly connected to the axle of the electric motor vehicle by the waveform shaper 4.

[0161] The ATP command speed signal 8 of the car receiver 7 is inputted to the first microcomputer 10 and the second microcomputer 11 of the ATP device 9 respectively and converted to control data or processed.

[0162] Namely, assuming the data corresponding to the ATP command speed signal is one word in length, n kinds of ATP command speed signals are converted to data of n words.

[0163] Control data generated by converting or processing by the microcomputers 10 and 11 is stored in the memory built in the microcomputers 10 and 11 and outputted as control data 12 and 13 sequentially.

[0164] The memory retaining the control data 12 and 13 may be the memories built in the microcomputers 10 and 11, or the memories or microcomputers (not shown in the drawing) built in the logical circuit 15 and the logical circuit 16, or a memory installed independently of the ATP device.

[0165] A memory or different memories may retain the control data 12 and 13.

[0166] Fig. 1 shows an example in which the above memory is built in each microcomputer.

[0167] Each of these memories may be a storage device including a cache memory.

(1) shown in Fig. 3 is generated by the first microcomputer 10 and shows data D_{ID} to DI_{x-1} stored at the addresses AI_0 to AI_{x-1} of the memory. In the same way, (2) shown in Fig. 3 is generated by the second microcomputer 11 and shows data DI_0 to DI_{x-1} stored at the addresses AI_0 to AI_{x-1} of the memory.

[0168] At the end of the data DI_0 to DI_{x-1} of the first microcomputer 10, CRC data D_{CRC1} one word in length is added for detection of a failure. The low-order bits to the high-order bits of the data DI_0 to DI_{x-1} and D_{CRC1} at the addresses AI_0 to AI_n are outputted serially. The outputted serial data is inputted to the logic circuit 15 of the system A as the control data 12 of the first microcomputer.

[0169] In the same way, at the end of the data DI_0 to DI_{x-1} of the second microcomputer 11, CRC data D_{CRC2} one word in length is added for detection of a failure. The low-order bits to the high-order bits of the data DI_0 to DI_{x-1} and D_{CRC2} at the addresses AI_0 to AI_n are outputted serially. The outputted serial data is inputted to the logic circuit 16 of the system B as the control data 13 of the second microcomputer.

[0170] In this case, it is desirable that the data DI_0 to DI_{x-1} is the same in both the systems A and B and this embodiment shows a case that the data is the same.

[0171] In the logic circuit 15 of the system A, the control data 12 is converted to n kinds of ATP command speed frequencies 151 according to the ATP command speed signals by the serial operation type frequency converter 150 (a ring arithmetic circuit described later) and outputted serially.

[0172] The serially outputted signals are inputted to the frequency comparator 152 (described later).

[0173] In the same way, in the logic circuit 16 of the system B, the control data 13 is converted to n kinds of ATP command speed frequencies 161 according to the ATP command speed signals by the serial operation type frequency converter 160 (a ring arithmetic circuit described later) and outputted serially.

[0174] The serially outputted signals are inputted to the frequency comparator 162 (described later).

[0175] In this case, D_{CRC1} of the system A and D_{CRC2} of the system B have CRC data generated by at least two different generation polynomial expressions respectively, that is, D_{CRC10} and D_{CRC11} for the system A and D_{CRC20} and D_{CRC21} for the system B. As to these CRC data, two CRC data may be generated from one CRC data.

[0176] These CRC data are not frequency-converted by the frequency converters 150 and 160.

[0177] The speed frequency 5 is inputted to the other one of the frequency comparator 152 of the system A and compared with the ATP command speed frequency 151 and the comparison result is outputted serially as the output signal 17.

[0178] In the same way, the speed frequency 5 is inputted to the other one of the frequency comparator 162 of the system B and compared with the ATP command speed frequency 161 and the comparison result is outputted serially as the output signal 18.

[0179] The matcher 20 compares and collates the output signal 17 of the logicircuit 15 and the output signal 18 of the logic circuit 16 and outputs a matched signal to the braking device 22 as the brake command 21.

[0180] Fig. 4 shows a conceptual diagram of the frequency comparison operation when an electric motor vehicle stops at the predetermined position and the relation between the ATP command speed frequency, the speed frequency of the electric motor vehicle, and the brake command will be explained.

[0181] In Fig. 4, the axis of ordinate indicates the ATP command speed frequency f_{ATP}, and the axis of abscissa indicates the time t, and a symbol f_V indicates the speed frequency of the electric motor vehicle.

[0182] The relation between the ATP command speed frequency f_{ATP0} and the speed frequency f_V of the electric motor vehicle at the time t_0 is $f_{ATP0} > f_V$. During the period from the time t_0 to t_1, neither the running command nor the brake command are given to the electric motor vehicle and the electric motor vehicle is in the state that it starts deceleration by coasting.

[0183] Assuming that the ATP command speed frequency f_{ATP0} is changed to f_{ATP1} at the time t_1 in this state, f_{ATP1} becomes lower than f_v, so that B_1 shown in the drawing is outputted from the matcher 20 as the brake command signal 21 and supplied to the braking device 22.

[0184] The braking force corresponding to the command is given to the electric motor vehicle from the braking device 22 and the electric motor vehicle starts deceleration.

[0185] Assuming that the ATP command speed frequency f_{APT1} is changed to f_{ATP2} at the time t_2, f_{ATP2} becomes lower than f_v, so that the brake command signal 21 of the matcher 20 becomes B_2 as shown in the drawing and the electric motor vehicle decelerates furthermore.

[0186] Assuming that the ATP command speed frequency is changed to f_{ATP3} to f_{ATP5} at the time t_3 to t_5 in the same way, B_3 to B_5 as shown in the drawing are outputted serially as the brake command signal 21 of the matcher 20. This brake command signal 21 is inputted to the braking device 22 and the braking device 22 gives the predetermined braking force to the electric motor vehicle.

[0187] In Fig. 1, the brake command signals 21 B_1 to B_5 are outputted serially from the matcher 20 as shown in Fig. 3, so that the braking device 22 decodes them and the braking device 22 is controlled so that the braking forces shown in Fig. 4 are operated.

[0188] As mentioned above, the ATP device is a main-

tenance device for giving braking force to an electric motor vehicle by an ATP command speed signal from the ground, controlling the speed of the electric motor vehicle, and stopping the electric motor vehicle at the predetermined stop position.

[0189] Namely, when one of the microcomputers 10 and 11, the logic circuits 15 and 16, and the matcher 20 constituting the ATP device breaks down and the predetermined brake command is not outputted, a serious accident may be caused, so that it is necessary to stop the electric motor vehicle surely when a failure of one of the aforementioned circuits and devices is detected.

[0190] This failure detection function will be explained hereunder.

[0191] The control data 12 inputted to the logical circuit 15 of the system A is checked by the failure detector 153 and the output signal 154 thereof is inputted to the failure detector of the system B.

[0192] The control data 13 inputted to the logical circuit 16 of the system B is checked by the failure detector 163 and the output signal 164 thereof is inverted in sign by the inverter 19 and inputted to the failure detector 153 of the system A as the sign inversion failure detection signal 165.

[0193] In this case, it is assumed that the signal voltage level at which the circuit does not operate is L and the signal voltage level at which the circuit operates is H.

[0194] When the control data 12 and 13 which are inputted to the logic circuits 15 and 16 of the systems A and B are normal, the output signals 154 and 164 of the failure detectors 153 and 163 become L. The output signal 164 of the failure detector 163 of the system B is inverted in sign by the inverter 19, so that the sign inversion failure detection signal 165 becomes H.

[0195] As to CRC data inputted to the failure detector 153 of the logical circuit 15, one of the two CRC data D_{CRC10} and D_{CRC11} is selected by the H-level sign inversion failure detection signal 165 of the logic circuit 16 and inputted to the failure detector 153 or the CRC data which is inputted first is changed to the other CRC data. For example, D_{CRC10} is controlled to be changed to D_{CRC11}.

[0196] It is desirable that the data possessed by each CRC data is the same in each of the systems A and B. In this embodiment, it is a precondition that all the data are the same. Namely, the data DI_0 to DI_{x-1} of each of the CRC data D_{CRC10}, D_{CRC11}, D_{CRC20}, and D_{CRC21} are the same.

[0197] On the other hand, CRC data inputted to the failure detector 163 of the logic circuit 16 is not changed to the other CRC data because the failure detection signal 154 is in the L state.

[0198] The processing is started from this state.

[0199] In this case, it is assumed that the CRC data of the control data 12 and 13 which are selected in each failure detector first is D_{CRC10} in the system A and D_{CRC20} in the system B.

[0200] Fig. 5 shows the relation of the operation waves between the number of operations, the output signal 154 of the failure detector 153, and the output signal 164 of the failure detector 163.

[0201] By the first operation, the control data 12 from the microcomputer 10 is supplied to the logic circuit 15 of the system A and the ATP command speed signal is converted to the predetermined command speed frequency f_{ATPn} by the logic circuit 15 and outputted as the output signal 17.

[0202] For the CRC data of this control data 12, D_{CRC11} which is incorrect CRC data is selected for the failure detector 153 by the H-level sign inversion failure detection signal 165 of the system B. Therefore, a failure is detected in the failure detector 153 and the failure detection signal 154 becomes H.

[0203] On the other hand, the control data 13 from the microcomputer 11 is supplied to the logic circuit 16 of the system B and the ATP command speed signal is converted to the predetermined command speed frequency f_{ATPn} by the logic circuit 16 and outputted as the output signal 18. The CRC data of this control data 13 is left unchanged as D_{CRC20} because the failure detection signal 154 of the system A is in the previous state, that is, in the L state. Therefore, the failure detection signal 164 of the failure detector 163 is left unchanged at L and the sign inversion failure detection signal 165 enters the H state.

[0204] Namely, at the end of the first operation, the failure detection signal 154 of the system A becomes H and the failure detection signal 164 becomes L.

[0205] By the second operation, the ATP command speed signal is converted to the predetermined command speed frequency f_{ATPn} and the output signals 17 and 18 are left unchanged. However, for the CRC data of the control data 12 to be inputted to the logic circuit 15 of the system A, D_{CRC11} is selected by the H-level sign inversion failure detection signal 165 of the system B and the failure detection signal 154 of the logic circuit 15 is held in the H state as mentioned above.

[0206] On the other hand, for the CRC data of the control data 13 to be inputted to the logic circuit 16 of the system B, D_{CRC21} is selected by the failure detection signal 154 which is in the H state which is the final state of the first operation of the system A.

[0207] Therefore, a failure is detected in the failure detector 163, and the failure detection signal 164 is changed from L to H, and the sign inversion failure detection signal 165 is changed from H to L.

[0208] Namely, at the end of the second operation, the failure detection signal 154 of the system A becomes H and the failure detection signal 164 also becomes H.

[0209] By the third operation, the ATP command speed signal is converted to the predetermined command speed frequency f_{ATPn} and the output signals 17 and 18 are left unchanged. However, the CRC data of the system A is changed from D_{CRC11} to D_{CRC10} because the sign inversion failure detection signal 165 of the system B is L.

[0210] Therefore, the failure detection signal 154 of the logic circuit 15 is changed from H to L.

[0211] On the other hand, for the CRC data of the control data 13 to be inputted to the logic circuit 16 of the system B, D_{CRC21} is selected by the failure detection signal 154 which is in the H state which is the final state of the second operation of the system A.

[0212] Therefore, a failure is detected in the failure detector 163, and the failure detection signal 164 is left unchanged in the H state, and the sign inversion failure detection signal 165 is also left unchanged in the L sate.

[0213] Namely, at the end of the third operation, the failure detection signal 154 of the system A becomes L and the failure detection signal 164 becomes H.

[0214] By the fourth operation, the ATP command speed signal is converted to the predetermined command speed frequency f_{ATPn} and the output signals 17 and 18 are left unchanged. However, since the sign inversion failure detection signal 165 of the system B to be inputted to the logic circuit 15 of the system A is L, the CRC data is left unchanged as D_{CRC10}.

[0215] Therefore, the failure detection signal 154 of the logic circuit 15 is left unchanged at L.

[0216] On the other hand, for the CRC data of the control data 13 to be inputted to the logic circuit 16 of the system B, D_{CRC20} is selected because the failure detection signal 154 of the system A is in the L state which is the final state of the third operation.

[0217] Namely, the failure detection signal 164 is changed from H to L and the sign inversion failure detection signal 165 is changed from L to H.

[0218] Namely, at the end of the fourth operation, the failure detection signal 154 of the system A becomes L and the failure detection signal 164 becomes L.

[0219] By the fifth operation, the ATP command speed signal is converted to the predetermined command speed frequency f_{ATPn} and the output signals 17 and 18 are left unchanged. However, since the sign inversion failure detection signal 165 of the system B to be inputted to the logic circuit 15 of the system A is H, for the CRC data, D_{CRC11} is selected.

[0220] Therefore, the failure detection signal 154 of the logic circuit 15 is changed from L to H.

[0221] On the other hand, for the CRC data of the control data 13 to be inputted to the logic circuit 16 of the system B, D_{CRC20} is selected because the failure detection signal 154 of the system A is in the L state which is the final state of the fourth operation. As a result, the failure detection signal 164 of the failure detector 163 is held in the L state and the sign inversion failure detection signal 165 is also held in the H state.

[0222] The processing is retumed to the first operation status and then the above operations are repeated.

[0223] In the aforementioned example, it is controlled so that when the failure detection signal 154 and the sign inversion failure detection signal 165 are in the L state, D_{CRC10} is selected in the system A and D_{CRC20} is selected in the system B and when they are in the H state, D_{CRC11} is selected in the system A and D_{CRC21} is selected in the system B. The relation between the failure detection signal and control of selection of the CRC data may be changed variously depending on the application.

[0224] Although it is assumed that D_{CRC10} in the system A and D_{CRC20} in the system B are correct data of the CRC data and D_{CRC11} in the system A and D_{CRC21} in the system B are incorrect data of the CRC data, they may be reversely assumed. In this case, correct and incorrect include that generation polynomial expressions of the CRC checker are different.

[0225] As mentioned above, the CRC data D_{CRC2} of the system B is controlled by the failure detection signal 154 of the logic circuit 15 of the system A and the CRC data D_{CRC1} of the system A is controlled by the sign inversion failure detection signal 165 of the failure detection signal 164 of the logic circuit 16 of the system B.

[0226] Therefore, when all the circuits such as the microcomputers 10 and 11 and the logic circuits 15 and 16 and the control data are normal, the failure detection signals 154 and 164 alternate in the fixed period.

[0227] By the way, the logic circuit 15, the failure detection signal 154, the logic circuit 16, and the failure detection signal 164 constitute a failure detection loop, so that a failure in this loop can be detected by a method for monitoring one of the failure detection signals 154 and 164.

[0228] However, a failure in a portion off this failure detection loop cannot be detected. To prevent an incorrect signal from outputting or a correct signal from not outputting due to a failure in a portion off this failure detection loop, the failure detection signal 154 of the system A and the failure detection signal 164 of the system B are collated by the matcher 20.

[0229] Fig. 4 is a drawing showing that an electric motor vehicle stops at the predetermined position and stops at the predetermined position by a brake command B_5 and shows a brake command 21 and braking force when the brake is put off for starting, for example, the logic circuit 15 of the system A breaks down.

[0230] When the alternation of the failure detection signal 154 of the system A and the failure detection signal 164 of the system B is stopped, the alternation of a failure detection collation output signal 24 is stopped. As a result, an emergency brake signal EB is outputted from the braking device 21 so as to apply the maximum braking force to the electric motor vehicle.

[0231] This emergency brake signal EB operates, as shown in Fig. 4, prior to the other brake commands B_1 to B_5.

[0232] By monitoring the alternation of one of the failure detection signals 154 and 164, it is possible to verify which one of the duplicated systems A and B breaks down, and the failure can be analyzed easily, and a fail safe system can be constructed effectively.

[0233] Fig. 6 shows a 1-bit fail safe matcher and Fig. 7 shows the operation waveforms thereof.

[0234] In Fig. 6, numeral 100 indicates a sign inverter, 101 a first flip-flop, 102 a second flip-flop, 103 an exclusive OR gate, 104 a collation output signal, 154 the failure detection signal of the logic circuit 15 shown in Fig. 1, and 164 the failure detection signal of the logic circuit 16 shown in Fig. 1.

[0235] Since the failure detection signals 154 and 164 alternate in the fixed period, the failure detection signal 154 is inputted to a clock terminal CK_1 of the first flip-flop 101.

[0236] When the failure detection signal 164 is inverted in sign by the inverter 100 and inputted to a clock terminal CK_2 of the second flip-flop 102, an output Q_1 of the first flip-flop 101 and a negative (inverted) output Q_2 of the second flip-flop 102 are formed as shown in Fig. 6.

[0237] When the output Q_1 of the first flip-flop 101 and the negative output Q_2 of the second flip-flop 102 are inputted to the exclusive OR gate 103, as shown in Fig. 6, the exclusive OR output signal 104 can be obtained.

[0238] When the alternation of one of the failure detection signals 154 and 164 is stopped or one of the flip-flops breaks down and the output terminal thereof is fixed to H or L, the alternation of the output signal 104 of the exclusive OR gate 103 is stopped.

[0239] Since the matcher collates two signals surely, the outputs thereof always alternate in the normal state. Therefore, by monitoring the output signal 104, not only the loop of the systems A and B but also the whole ATP device can be decided as to whether they are normal or abnormal. Conversely speaking, it is desirable to monitor only this output signal 104.

[0240] Fig. 6 shows a fail safe matcher for collating a 1-bit output. To collate a plurality of bits in fail safe, it is desirable to prepare only the circuit collating drawing shown in Fig. 6. The matcher 20 shown in Fig. 1 is equivalent to that the circuit shown in Fig. 6 has a plurality of bits built-in.

[0241] Therefore, it is desirable that a controller or a system for receiving an output signal from the ATP device has a constitution for outputting an emergency control signal because the outputting of alternating signals of the matcher 20 is stopped and it is made possible to construct a system for realizing fail safe surely by this constitution.

[0242] The aforementioned is an explanation of an embodiment in which the brake command 21 of the matcher 20 is outputted serially. However, it is possible that B_1, B_2, B_3, B_4, and B_5 of the brake command 21 are outputted to the braking device 22 respectively in parallel. In other words, it is desirable that the matcher 20 is structured so that the command becomes a signal necessary for the braking device 22.

[0243] As mentioned above, when a memory retaining control data is not built in the microcomputer but in the ATP device or it is installed independently, a dedicated memory reading signal line, a writing signal control circuit, and an address signal generation circuit are necessary in the logic element which is the controller 14. However, it is possible that the microcomputer and the controller only transmit and receive information via the memory and the microcomputer can be used for other control processing, so that the use efficiency of the microcomputer can be increased.

[0244] In this embodiment, an example in which there are two CRC data provided for one logic circuit and they are switched by a failure detection signal from another logic circuit. However, as mentioned in Fig. 18, it can be realized easily that the content of the data is not checked, and just alternating signals are generated, and whether the two logic circuits operate normally or abnormally is outputted.

[0245] Next, another embodiment will be explained with reference to Fig. 8.

[0246] In Fig. 8, as in Fig. 1, the same circuit is mounted on one chip as duplicated as the systems A and B. As mentioned above, the ATP device is a maintenance device necessary for safety running of an electric motor vehicle and it is never permitted that an incorrect signal is outputted or the predetermined signal is not outputted due to a failure in the ATP device. Therefore, the failure detection function in the embodiment shown in Fig. 8 is strengthened furthermore.

[0247] In Fig. 8, each same code as that shown in Fig. 1 has the same function, so that the explanation thereof will be omitted.

[0248] In Fig. 8, numeral 30 indicates a first memory mounted in the logic circuit 15 of the system A, 31 a second memory, 32 CRC data of control data 120 stored in the first memory 30, 33 CRC data of control data 121 stored in the second memory 31, 34 a switching circuit for the first memory 30 and the second memory 31, 35 an output signal of the memory switching circuit 34, 36 a first CRC check circuit for the control data 120 stored in the first memory 30, 37 a second CRC check circuit for the control data 121 stored in the second memory 31, 38 a first OR circuit for adding the output signal 35 of the switching circuit 34 and an output signal of the second CRC check circuit 37, and 39 a second OR circuit for adding an output signal of the first CRC check circuit 36 and the speed frequency 5 corresponding to the running speed of an electric motor vehicle.

[0249] Numeral 40 indicates a first memory mounted in the logic circuit 16 of the system B, 41 a second memory, 42 CRC data of control data 130 stored in the first memory 40, 43 CRC data of control data 131 stored in the second memory 41, 44 a switching circuit for the first memory 40 and the second memory 41, 45 an output signal of the memory switching circuit 44, 46 a first CRC check circuit for the control data 130 stored in the first memory 40, 47 a second CRC check circuit for the control data 131 stored in the second memory 41, 48 a first OR circuit for adding the output signal 45 of the switching circuit 44 and an output signal of the second CRC check circuit 47, and 49 a second OR circuit for adding an output signal of the first CRC check circuit 46 and the

speed frequency 5 corresponding to the running speed of an electric motor vehicle.

[0250] The ATP command speed signal 8 is processed by the microcomputers 10 and 11 and the respective control data is inputted to the logic circuits of the systems A and B of the 1-chip logic element 14.

[0251] Namely, the first control data 120 from the microcomputer 10 is stored in the first memory 30 of the system A, and the second control data 121 is stored in the second memory 31 of the system A, and the third control data 130 from the microcomputer 11 is stored in the first memory 40 of the system B, and the second control data 131 is stored in the second memory 41 of the system B.

[0252] Fig. 9 shows data which is stored in the memories 30, 31, 40, and 41 from the microcomputers 10 and 11.

[0253] The microcomputer 10 converts the ATP command speed signal 5 to n-word data D_{0X} to D_{14X}, processes and obtains the CRC data 32 (data is D_{CRCX1}) of the data D_{0X} to D_{14X} when the generation polynomial expression is set to G0(X) at the same time, and stores the data in (1) shown in Fig. 9 in which the CRC data 32 (data is D_{CRCX1}) is added to the data D_{0X} to D_{14X} at the addresses AOS to A15S of the first memory 30.

[0254] The microcomputer 10 processes and obtains the CRC data 33 (data is D_{CRCX2}) of the data D_{0X} to D_{14X} when the generation polynomial expression is set to G1(X) and stores the data in (2) shown in Fig. 9 in which the CRC data 33 (data is D_{CRCX2}) is added to the data D_{0X} to D_{14X} at the addresses AOT to A15T of the second memory 31.

[0255] The microcomputer 11 converts the ATP command speed signal 5 to n-word data D_{0Y} to D_{14Y}, processes and obtains the CRC data 42 (data is D_{CRCY1}) of the data D_{0Y} to D_{14Y} when the generation polynomial expression is set to G2(X) at the same time, and stores the data in (3) shown in Fig. 9 in which the CRC data 42 (data is D_{CRCY1}) is added to the data D_{0Y} to D_{14Y} at the addresses A0U to A15U of the first memory 40.

[0256] The microcomputer 11 processes and obtains the CRC data 43 (data is D_{CRCY2}) of the data D_{0Y} to D_{14Y} when the generation polynomial expression is set to G3(X) and stores the data in (4) shown in Fig. 9 in which the CRC data 43 (data is D_{CRCY2}) is added to the data D_{0Y} to D_{14Y} at the addresses A0V to A15V of the second memory 41.

[0257] The data which is stored at the addresses A0S to A15S of the first memory 30 of the system A and the addresses A0T to A15T of the second memory 31 are converted from parallel to serial, read sequentially from the low-order bits to the high-order bits, and inputted to the switching circuit 34.

[0258] In the same way, the data which is stored at the addresses A0U to A15U of the first memory 40 of the system B and the addresses A0V to A15V of the second memory 41 are converted from parallel to serial, read sequentially from the loworder bits to the high-order bits, and inputted to the switching circuit 17.

[0259] The period from reading the addresses A0n to A15n to processing by the frequency comparators 152 and 162 is one processing period.

[0260] The first CRC check circuit 36 of the system A is a circuit corresponding to the generation polynomial expression G0(X) and the second CRC check circuit 37 is a circuit corresponding to the generation polynomial expression G1(X).

[0261] The third CRC check circuit 46 of the system B is a circuit corresponding to the generation polynomial expression G2(X) and the fourth CRC check circuit 47 is a circuit corresponding to the generation polynomial expression G3(X).

[0262] It is assumed that the failure detection signal 154 of the system A and the failure detection signal 164 of the system B are in the L state first. Therefore, the sign inversion failure detection signal 165 of the system B is H.

[0263] By this H-state sign inversion signal 165 of the system B, the switching circuit 34 of the system A is switched to the side for reading the data of the first memory 30, and the switching circuit 44 of the system B is switched to the side for reading the data of the second memory 41 by the L-state sign inversion signal 154 of the system A, and all the data and the internal circuit are assumed to be normal.

[0264] The data D_{0X} to D_{14X} at the addresses AOS to A14S of the first memory 30 of the system A and the data D_{0X} to D_{14X} at the addresses A0T to A14T of the second memory 31 are inputted to the frequency converter 150 via the switching circuit 34 and the first logic circuit 38 and converted to the ATP command speed frequency f_m corresponding to the respective data, whereas the the data D_{0X} to $D1_{4X}$ at the addresses A0S to A14S and AOT to A14T are inputted to the first CRC check circuit 36 and the second CRC check circuit 37 and checked by the CRC data D_{CRCX1} and D_{CRCX2} at the addresses A15S and A15T.

[0265] Therefore, it is structured so that until the CRC data D_{CRCX1} and D_{CRCX2} at the addresses A15S and A15T are all read and checked, the intermediate check result for the first check circuit 36 and the second check circuit 37 is not outputted.

[0266] The CRC data D_{CRCX1} and D_{CRCX2} at the addresses A15S and A15T are structured not to be frequency-converted.

[0267] In the same way, the data D_{0Y} to D_{14Y} at the addresses A0U to A14U of the first memory 40 of the system B and the data D_{0Y} to D_{14Y} at the addresses A0V to A14V of the second memory 41 are inputted to the frequency converter 160 via the switching circuit 44 and the first logic circuit 48 and converted to the ATP command speed frequency f_m corresponding to the respective data, whereas the the data D_{0Y} to D_{14Y} at the addresses A0U to A14U and A0V to A14V are inputted to the first CRC check circuit 46 and the second CRC check circuit 47 and checked by the CRC data D_{CRCY1}

and D_{CRCY2} at the addresses A15U and A15V.

[0268] Therefore, it is structured so that until the CRC data D_{CRCY1} and D_{CRCY2} at the addresses A15U and A15V are all read and checked, the intermediate check result for the first check circuit 46 and the second check circuit 47 is not outputted.

[0269] The CRC data D_{CRCY} and D_{CRCY2} at the addresses A15U and A15V are structured not to be frequency-converted.

[0270] Firstly, the one-word data at the address A0S of the first memory 30 of the system A is inputted to the frequency converter 150 via the OR circuit and converted to the ATP command speed frequency fr0 corresponding to the one-word data.

[0271] On the other hand, since the first CRC check circuit 36 and the second CRC check circuit 37 are checking data, the outputs thereof are L.

[0272] Next, the one-word data at the address AIS is inputted to the frequency converter 150 via the OR circuit 38 and converted to the ATP command speed frequency f_{r1} corresponding to the one-word data at the address A1S. On the other hand, the input frequency f_{il} which is an output of the OR circuit 39 is L.

[0273] Hereafter, in the same way, each one-word data is converted to the ATP command speed frequency f_{r14} corresponding to the data up to the address A14S.

[0274] The one-word CRC data D_{CRCX1} (data by the generation polynomial expression G0(X)) at the last address A15S is decided as normal by the first CRC check circuit 36 (circuit corresponding to the generation polynomial expression G0(X)), so that the output thereof is L. However, since the one-word CRC data D_{CRCX1} is decided as abnormal by the second CRC check circuit 37 (circuit corresponding to the generation polynomial expression G1(X)), the output thereof is H.

[0275] The output of this second CRC check circuit is inputted to the frequency converter 150 as maximum data via the OR circuit 38 and converted to the maximum frequency f_{r15}.

[0276] On the other hand, the input frequency f_{i15} which is an output of the OR circuit 39 is L.

[0277] The frequency f_{rn} corresponding to the data at each address which is obtained in this way and the input frequency f_{in} are compared by the frequency comparator 152.

[0278] In the frequency comparator 152, when the relation between the ATP command speed frequency frn and the addition frequency f_{in} is $f_{rn} > f_{in}$, 1 is added to the internal counter value (not shown in the drawing), and when the relation is $f_{rn} < f_{in}$, 1 is subtracted from the counter value, and when $f_{rn} = f_{in}$, nothing is added to or subtracted from the counter value.

[0279] In the first processing period, 1 is added to the counter value in correspondence to the addresses AOS to A14S. In the second processing period, the data is read from the address A0S again and the counter value of the frequency comparator 152 is incremented by the same operation as that mentioned above.

[0280] When the fourth processing period elapses and the counter value of the frequency comparator 152 reaches 4, the output signal 17 corresponding to each of the addresses from A0S to A15S is obtained.

[0281] Fig. 10 shows the relation between the operation of the counter of the frequency comparator 152 due to the CRC check result at the address A15S of the system A, the operation of the counter of the frequency comparator 162 due to the CRC check result at the address A15U of the system B, and the sign inversion signal 165 which inverts the sign of the failure detection signal 164.

[0282] When the counter value reaches 4 by an up-count pulse, the output signal 17 of the frequency comparator 152 is obtained. Since this output signal 17 is outputted serially, the frequency comparator 152 detects the H-state failure detection signal 154 corresponding to the address A15S in synchronization with the timing signal (not shown in the drawing) and inputs it to the memory switching circuit 44 of the system B.

[0283] The switching circuit 44 switches the memory 41 to the memory 40 in exact timing with the beginning of the next processing period, so that the memory of the system B is actually switched at the beginning of the sixth processing period.

[0284] The data stored at the addresses AOU to A14U of the memory 40 is exactly the same as the data stored at the addresses AOV to A14V of the memory 41, so that even if the memory 41 is switched to the memory 40, the ATP command speed frequency f_{rn} will not be changed and the input frequency f_{in} will not be changed.

[0285] Therefore, the output frequency of the frequency converter 160 will not be changed. Only the CRC data 42 (D_{CRCY1}) stored at the address A15U and the CRC data 43 (D_{CRCY2}) stored at the address A15V are different, so that the operation when the data at the addresses A15U and A15V are read will be explained.

[0286] When the memory 41 is switched to the memory 40, the CRC data 42 (data by the generation polynomial expression) is read. Since the CRC data 42 is decided as normal by the first CRC check circuit 46 (circuit corresponding to the generation polynomial expression G2(X)), the output thereof is L. However, since it is decided as abnormal by the second CRC check circuit 47 (circuit corresponding to the generation polynomial expression G3(X)), the output thereof is H.

[0287] Since the output of the first CRC check circuit 46 is L, the output of the OR circuit 49 is also L and the input frequency f_{i15} is also L.

[0288] On the other hand, the H-state output of the second CRC check circuit 47 is inputted to the frequency converter 160 via the OR circuit 48 and converted to the maximum frequency f_{r15}.

[0289] This maximum frequency f_{r15} and the input frequency f_{i15} are inputted and compared by the frequency comparator 162. Since the relation between the maximum frequency f_{r15} and the input frequency f_{i15} is $f_{r15} > f_{i15}$, the counter value of the frequency comparator 162

is incremented to 1.

[0290] Hereafter, by the same operation as that of the system A, the counter value of the frequency comparator 162 is incremented and when the counter value reaches 4, the output signal 18 corresponding to each of the addresses from A0U to A15U is obtained.

[0291] The frequency comparator 162 detects the H-state failure detection signal 164 corresponding to the address A15U of this output signal 18 in synchronization with the timing signal (not shown in the drawing) and adds the L-state sign inversion signal 165 which is inverted in sign by the inverter 19 to the memory switching circuit 34 of the system A.

[0292] When the sign inversion signal 165 is inputted, the memory switching circuit 34 of the system A switches the memory 30 to the memory 31 from the next 11th period.

[0293] Only the CRC data 32 (D_{CRCX1}) stored at the address A15S and the CRC data 33 (D_{CRCX2}) stored at the address A15T are different between the memory 30 and the memory 31, so that the frequency will not be changed when the memory is switched as mentioned above.

[0294] Since the CRC data 33 of the memory 31 is data by the generation polynomial expression G1(X), it is decided as abnormal by the CRC check circuit 36 and the output signal thereof becomes H. This output signal is inputted to the frequency converter 152 as a maximum frequency f_{i15} via the second OR circuit 39.

[0295] On the other hand, since the CRC data 33 of the memory 31 is data by the generation polynomial expression G1(X), it is decided as normal by the CRC check circuit 37, and the output signal thereof becomes L, and the output signal of the OR circuit 38 also becomes L, and the reference frequency f_{r15} of the frequency converter 150 also becomes L.

[0296] Therefore, the relation between the reference frequency f_{r15} and the input frequency f_{i15} becomes $f_{r15} < f_{i15}$ and a count-down pulse is given, so that 1 is subtracted from the counter value of the frequency comparator 152 and the counter value is changed from 4 to 3.

[0297] When the counter value of the frequency comparator 152 becomes 0, the output signal 17 of the frequency comparator 152 also becomes L and the failure detection signal 154 corresponding to the address A15T becomes L.

[0298] By the same operation hereafter, the memory of the opposite system is switched alternately by a failure detection signal of the frequency comparator of the own system.

[0299] When the memories 30 and 31 of the system A, data read from them, the two CRC check circuits 36 and 37, the memories 40 and 41 of the system B, data read from them, and the two CRC check circuits 46 and 47 are normal as mentioned above, the failure detection signals 154 and 164 change alternately to H or L respectively whenever the memory is changed.

[0300] For example, when an error occurs in the data of the memory 30 of the system A, the following is caused. The data error of the memory 30 is detected by the CRC check circuit 36 and the output signal thereof becomes H.

[0301] On the other hand, CRC data by a different generation polynomial expression is inputted to the CRC check circuit 37 from the beginning, so that the output signal thereof also becomes H. Namely, since the output signals of both the check circuits become H, neither the counter value of the frequency comparator 152 nor the output will be changed.

[0302] Therefore, the failure detection signal 154 for switching the memory 41 of the system B to the memory 41 is fixed to H or L which is the state when a failure occurs and the memory cannot be switched from 41 to 40.

[0303] As a result, the counter value of the frequency comparator 162 will not be incremented and the failure detection signal is fixed to the L state. Therefore, the sign inversion failure detection signal 165 is fixed to H, and the memory 30 of the system A is not switched to the memory 31, and the output signals of the CRC check circuits 36 and 37 are fixed to H.

[0304] The above is an example when an error occurs in data. However, when one of the circuits breaks down, the counter values of the frequency comparators 152 and 162 are fixed as a result and the alternation of the failure detection signals 154 and 164 is stopped, so that it is desirable to monitor the alternation of the failure detection signals 154 and 164.

[0305] When such a method for generating a signal is applied to the ATP device of a train, it can be used as a means for commanding an emergency brake when the alternation of the failure detection signals 154 and 164 is stopped.

[0306] When this circuit comprises an LSI and is integrated to one chip including the peripheral circuit, miniaturization and mass production can be realized with the reliability as an ATP device kept.

[0307] Since the ATP device constitutes a failure detection loop together with the failure detection signal 154 and the failure detection signal 164 as mentioned above, a failure within the loop can be detected by monitoring one of the failure detection signals 154 and 164, though a failure in a position off this failure detection loop cannot be detected. To prevent an incorrect signal from being outputted or a correct signal from not being outputted due to a failure in a position off this failure detection loop, the failure detection signals 154 and 164 are collated by the matcher 20, and when a match occurs, the matcher 20 outputs a signal, and when a mismatch occurs, the matcher 20 outputs an emergency control signal.

[0308] The matcher 20 compares the output signal 17 of the frequency comparator 152 of the system A and the output signal 18 of the frequency comparator 162 of the system B. As mentioned above, since the output signal 17 and the output signal 18 are outputted serially in

the order of address signals, the matcher 20 compares the signal corresponding to each address respectively and outputs only a matched signal. When a mismatch occurs, the matcher 20 can output an emergency control signal or display it on the display unit.

[0309] Therefore, by using this constitution, a fail safe system can be constructed.

[0310] As mentioned above, according to the present invention, two CRC data in which different generation polynomial expressions are applied to one data are prepared, and two systems of control data to which the CRC data are added are produced, and two kinds of check circuits corresponding to different generation polynomial expressions are provided.

[0311] This is a method for inputting the two systems of control data to the two kinds of check circuits at the same time and switching the two systems of data using the result obtained by comparing the outputs of the two kinds of check circuits.

[0312] Therefore, an error can be detected not only in the data but also in the check circuits and furthermore outputs are collated and only when a match occurs, they can be outputted. There is an advantage that a fail safe system can be structured more surely by using a chip in which each of the circuits comprises an LSI.

[0313] Next, the operation of the frequency converter 150 (160) shown in Figs. 1 and 8 will be explained hereunder.

[0314] Fig. 11 shows a frequency converter for converting digital data to a frequency and Fig. 12 is a flow chart of the operation of the frequency converter.

[0315] In Fig. 11. numeral 50 indicates a memory, 51 a clock signal C_N, 52 a data register, 53 an output signal of the data register 52, 54 all 1-bit adders, 55 an addition output of all the adders 54, 56 a clock signal C_P, 57 a processing shift register, 58 an output signal of the shift register 57, 59 a first flip-flop for timing adjustment, 60 an output signal of the flip-flop 59, 61 a carrier output signal of all the adders 54, 62 a second flip-flop for holding the carrier output signal 61, 63 an output signal of the flip-flop 62, 64 a timing signal, 65 an AND circuit for removing the predetermined output signal from the carrier output signal 61, and 66 an output signal of the frequency converter.

[0316] For simple explanation of the operation, it is assumed that the data length is 4 bits, and data of the same value is periodically read from the memory 50, and data of the data register 52 and the shift register 57 is shifted in the direction of the arrow shown on the upper part.

[0317] The clock signal C_N51 and the clock signal C_P56 are clock signals which are different in phase by 90° as shown in (1) and (2) in Fig. 12.

[0318] In the initial state, the initial values of the data register 52 and the shift register 57 are 02 (this means that the data value in binary is zero).

[0319] It is assumed that the data value 82 (the data value in binary is 8) as shown in (3) in Fig. 12 is read at the leading edge of the clock signal C_P56 from the memory 50. Since this data is set in the data register 52 at the leading edge of the clock signal C_N51, the most significant DR_3 bit to the least significant DR_0 bit are set as shown in (4) in Fig. 12.

[0320] When the data in (4) shown in Fig. 12 is shifted four times at the leading edge of the clock signal C_N51, the value of the least significant DR_0 bit of the data register 52 is set as shown in (7) in Fig. 12 and added to the input terminal A of all the adders 54 as the output signal 53.

[0321] In this case, the output signal 60 of the first flip-flop 59 and the output signal 63 of the second flip-flop 62 are not added to the input terminals B and C of all the adders 54, so that the output signal 55 at the addition output terminal Σ of all the adders 54 becomes H as shown in (8) in Fig. 12 and is added to the shift register 57. The output signal 61 at the carrier output terminal C_r of all the adders 54 becomes L as shown in (14) in Fig. 12.

[0322] Since the output signal 55 of all the adders 54 is set in the shift register 57 at the leading edge of the clock signal C_P56 shown in (2) in Fig. 12, the most least bit SR_0 of the shift register 57 is set as shown in (9) in Fig. 12.

[0323] The data value 82 (8 in decimal) is read from the memory 50 at the leading edge of the same clock signal C_P56 and shifted on the data register 52 at the leading edge of the clock signal C_N51.

[0324] On the other hand, the data of the least significant bit SR_0 of the shift register 57 is shifted on the shift register 57 at the leading edge of the clock signal C_P56; and the most significant bit SR_3 becomes H in the middle of the 7th shift, and the output signal 58 of the shift register 57 becomes H.

[0325] Since the output signal 58 is set in the first flip-flop 59 at the leading edge of the clock signal C_P56, the output signal 60 thereof becomes H at the 8th shift as shown in (13) in Fig. 12 and is inputted to the input terminal B of all the adders 54.

[0326] On the other hand, the least significant bit DR_0 of the data register 52 also becomes H at the 8th shift and is inputted to the input terminal A of all the adders 54.

[0327] As a result, the output signal 55 at the addition output terminal Σ of all the adders 54 becomes L, though the output signal 61 of the carrier output terminal C_r becomes H. This output signal 61 is set in the second flip-flop at the leading edge of the next clock signal C_N51 and the output signal 63 shown in (15) in Fig. 12 is inputted to the input terminal C of all the adders 54.

[0328] Therefore, the output signal 55 of the addition output terminal Σ of all the adders 54 becomes H and is shifted on the shift register 57.

[0329] Since the operation explained above is repeated periodically, the data shown in Fig. 12 move around in the data register 52 and the shift register 57. By adding the carrier output signal 61 of all the adders 54 which

is generated at this time to the AND gate and fetching it by the timing signal 64, the output signal 66 in the fixed period as shown in (16) in Fig. 12 can be obtained.

[0330] The above is the explanation of the operation when one kind of digital data is converted to one frequency. To obtain two kinds of frequencies, different data are read and processed alternately from the memory 50. Therefore, it is desirable to double the number of bits of the shift register 57 to 8 bits and prepare two AND gates and a timing signal so as to take out the predetermined frequency from the carrier output signal 61 of all the adders 54. By changing the bit length of the shift register 57 like this, the frequency converter shown in Fig. 10 can generate a multi-frequency.

[0331] Next, the frequency comparison operation shown in Figs. 1 and 8 will be explained. A frequency comparator is shown in Fig. 13 and an operation timing chart is shown in Fig. 14. In Fig. 13, numerals 70 to 73 indicate flip-flops, 74 to 79 AND gates, P and M input frequency signals to be compared, and 80 an output signal of the frequency comparison result.

[0332] For example, when the P signal is inputted, it inverts and operates one of those among the flip-flops 70 to 73 which are closest to the input to Q = H and when the M signal is inputted inversely, it inverts and operates one of those among the flip-flops 70 to 73 which are Q = H and closest to the input to Q = L.

[0333] When the input signal P is inputted continuously as shown in Fig. 14, the flip-flop 70 operates in synchronization with the trailing edge of the first pulse P_1 of the signal P and Q_0 becomes H, and when the second pulse P_2 is inputted, the flip-flop 71 operates in synchronization with the trailing edge of the output of the AND gate 74 and Q_1 becomes H, and when the third pulse P_3 is inputted, the flip-flop 72 operates in synchronization with the trailing edge of the output of the AND gate 76 and Q_2 becomes H, and when the fourth pulse P_4 of the signal P is inputted, the flip-flop 73 operates in synchronization with the trailing edge of the output of the AND gate 78 and Q_3 becomes H.

[0334] When the input signal M is inputted continuously, the flip-flop 70 operates in synchronization with the trailing edge of the first pulse M_1 of the signal M and Q_0 is changed from H to L, and when the second pulse M_2 is inputted, the flip-flop 71 operates in synchronization with the trailing edge of the AND gate 75 and Q_1 is changed from H to L, and when the third pulse M_3 is inputted, the flip-flop 72 operates in synchronization with the trailing edge of the AND gate 77 and Q_2 is changed from H to L, and when the fourth pulse M_4 is inputted, the flip-flop 73 operates in synchronization with the trailing edge of the AND gate 79 and Q_3 is changed from H to L.

[0335] As mentioned above, when the number of pulses is large, the output state of the flip-flop on the subsequent stage can be inverted and when P > M, Q_3 of the flip-flop FF_3 becomes H, that is, the output signal 80 of the frequency comparison result becomes H. When P < M, the output signal 80 becomes L.

[0336] When a multi-frequency is compared, the constitution shown in Fig. 15 is used. In Fig. 15, numeral 90 indicates a shift register having the number of bits equivalent to a length of 4 bits which is equivalent to the flip-flops 70 to 73 shown in Fig. 13 and 91 indicates an adder having a function for allowing data on the shift register 90 to perform the same operation as the inversion of the flip-flops 70 to 73 shown in Fig. 13.

[0337] A symbol I_n indicates a time slot in which 4 bits are grouped and the slot inputs the signal P to the +A terminal of the adder 91 and inputs the signal M to the -C terminal. It is assumed that P > M.

[0338] The frequency comparison operation compares the presence or absence of a pulse, so that P = H and M = L in this state. Since the sign inversion signal H of M is inputted to the -C terminal and added, the carrier output C_r becomes H and this value is added to the I_0 slot of the shift register 90.

[0339] The data of this I0 slot moves around on the shift register, is inputted to the +B terminal of the adder 91 at the I_0 slot in the next period, and added together with the P input and the M input, so that the carrier output C_r of the adder becomes H also in this case and the data of the same value as the previous one moves around on the shift register 90.

[0340] When P < M, a signal L in which the signs of P = L and M = H are inverted is added, so that the carrier output C_r becomes L, that is, is subtracted and the value is added to the I_0 slot of the shift register 90. Namely, L moves around on the shift register 90.

[0341] When P = M = H, a signal L in which the signs of P = L and M = H are inverted is added. However, the value of the carrier output C_r varies with the data of the I_0 slot which moves around on the shift register 90. When the data of the I_0 slot is L, the carrier output C_r also becomes L and when the data of the I_0 slot is H, the carrier output C_r becomes H. Namely, the data of the I_0 slot moving around on the shift register 90 will not be changed.

[0342] When P = M = L, a signal H in which the signs of P = L and M = H are inverted is added. Also in this case, the value of the carrier output C_r varies with the data of the I_0 slot which moves around on the shift register 90. When the data of the I_0 slot is L, the carrier output C_r also becomes L and when the data of the I_0 slot is H, the carrier output C_r becomes H. Namely, the data of the I_0 slot moving around on the shift register 90 will not be changed.

[0343] The frequency comparison operation is performed by this method.

[0344] Fig. 16 shows another embodiment of the present invention. According to the embodiment shown in Fig. 8, the system A has two circuits of the memories 30 and 31 in the logic circuit 15 and the output data 35 is obtained by selecting data outputted from each memory by the switching circuit 34. Also the system B has two circuits of the memories 40 and 41 in the logic circuit

16 and the output data 45 is obtained by selecting data outputted from each memory by the switching circuit 44.

[0345] A difference of the embodiment of the present invention shown in Fig. 16 from that shown in Fig. 8 is that each of memories in the logic circuits 15 and 16 of the systems A and B comprises one circuit and the CRC data allocated at the last address of each memory is stored in another area and switched by the aforementioned failure detection signal.

[0346] Namely, the CRC data D_{CRCX1} which is calculated by the microcomputer 10 by the same method as the aforementioned is stored in the memory 32 of the system A, and D_{CRCX2} is stored in the memory 33, and D_{CRCY1} which is calculated by the microcomputer 11 is stored in the memory 42 of the system B, and D_{CRCY2} is stored in the memory 43.

[0347] In the system A, the data read from the memory 30 is added to the CRC data 32 by the logic circuit 200, and the data read from the memory 30 is added to the CRC data 33 by the logic circuit 201, and they are inputted to the switching circuit 34.

[0348] In the system B, the data read from the memory 40 is added to the CRC data 42 by the logic circuit 202, and the data read from the memory 40 is added to the CRC data 43 by the logic circuit 203, and they are inputted to the switching circuit 44. The switching timing for the switching circuits 34 and 44 is the same as the aforementioned.

[0349] In another embodiment of the present invention shown in Fig. 16, the number of memories requiring the maximum number of gates can be reduced by half, so that it not only greatly contributes to improvement of the reliability but also has a great effect on reduction of power consumption of the LSI.

[0350] Fig. 17 shows another embodiment of the present invention. Fig. 17 also shows an example in which each built-in memory comprises one circuit. A difference between Fig. 8 and Fig. 16 is that although the output of each memory is switched by the switching circuit in Fig. 8, the CRC data is switched in Fig. 16. The CRC data D_{CRCX1} which is calculated by the microcomputer 10 by the same method as the aforementioned is stored in the memory 32 of the system A and D_{CRCX2} is stored in the memory 33 continued to the memory 32. D_{CRCY1} which is calculated by the microcomputer 11 is stored in the memory 42 of the system B and D_{CRCY2} is stored in the memory 43 continued to the memory 42.

[0351] The CRC data is switched by the switching circuits 204 and 205 using the failure detection signal 154 and the sign inversion failure detection signal. Also in another embodiment of the present invention shown in Fig. 17, the number of memories requiring the maximum number of gates can be reduced by half, so that it not only greatly contributes to improvement of the reliability but also has a great effect on reduction of power consumption of the LSI.

[0352] Fig. 18 shows another embodiment of the present invention. Fig. 18 also shows an example in which each built-in memory comprises one circuit. A difference from Fig. 17 is that the CRC data is switched by each switching circuit and then the output signal of each memory and the output signal of each switching circuit are added by the adder.

[0353] The switching circuit 34 of the system A switches the CRC data 32 and the CRC data 33 by the sign inversion failure detection signal 165 and the switching circuit 44 of the system B switches the CRC data 42 and the CRC data 43 by the failure detection signal 154. Also in another embodiment of the present invention shown in Fig. 18, the number of memories requiring the maximum number of gates can be reduced by half and furthermore the number of adders also can be reduced by half, so that it not only greatly contributes to improvement of the reliability but also has a great effect on reduction of power consumption of the LSI.

[0354] Fig. 19 is a schematic layout diagram of another embodiment of the present invention shown in Fig. 8. Numeral 300 indicates a bus interface for transmitting and receiving data to or from the microcomputer 10, 301 and 302 memories for storing data, 303 a processor such as a memory switching circuit, a frequency converter, and a frequency comparator, 304 a bus interface for transmitting and receiving data to or from the microcomputer 11, 305 and 306 memories for storing data, 307 a processor such as a memory switching circuit, a frequency converter, and a frequency comparator, and 308 a matcher for an output signal of the processor 303 of the system A and an output signal of the processor 307 of the system B.

[0355] When the systems A and B are duplicated and arranged away from each other, an effect of a failure of one system on the other system, for example, an effect such that although one system is broken down, a signal as if it is normal is outputted can be prevented.

[0356] When the circuits constituting the matcher unit are arranged away from each other and the conductor interval is extended, an effect such that a failure of one of the matchers affects the other matchers and a command signal is not outputted or outputted can be prevented.

[0357] Another embodiment of the present invention is shown in Fig. 20 and will be explained hereunder. Fig. 20 is a drawing showing an embodiment in which a plurality of processors which are the same as the one shown in Fig. 2 are provided.

[0358] Numeral 2000 indicates a controller, 2010 a first processor for inputting and processing first input data and outputting first output data 2100 and a first detection signal 2140, 2020 a second processor for outputting second output data 2110 and a second detection signal 2150, 2030 a third processor for outputting third output data 2120 and a third detection signal 2160, 2040 a fourth processor for outputting fourth output data 2130 and a fourth detection signal 2170, 2180 a first transmitter for transmitting the first detection signal 2140 outputted from the first processor 2010 to the second proces-

sor 2020, 2190 a second transmitter for transmitting the second detection signal 2150 outputted from the second processor 2020 to the third processor 2030, and 2200 a third transmitter for transmitting the third detection signal 2160 outputted from the third processor 2030 to the fourth processor 2040.

[0359] By using such a duplicated constitution that by using each failure detection signal, the CRC data of the corresponding detector is switched, only when all the data, circuits, and elements operate normally, an output signal for controlling the object to be controlled is outputted and when a failure is detected in a part, no output signal is outputted. Therefore, when a failure occurs, a fail safe function for controlling on the safety side is made possible.

[0360] According to the present invention, as mentioned above, a controller having an extremely high fail safe performance and a system using it can be realized.

[0361] Further features of some or all embodiments of the present invention may be as described below in the remainder of this specification.

[0362] In a first aspect, the invention may include a controller characterised in that said controller has a plurality of processors for inputting input signals and outputting output signals obtained by executing a plurality of operations and inputs an output signal of a first processor among said plurality of processors to second processors including at least one processor among said plurality of processors and inputs output signals of said second processors to said first processor and the polarity of one of said output signals of said second processors is inverted to that of said input signals of said first processor.

[0363] Preferably the invention includes a logic circuit or a controller
wherein when one of said input signals of said first processor makes a closed loop via said second processors, the polarity thereof is inverted.

[0364] In a second aspect, the invention may include a controller characterized in that said controller has a first processor for inputting an input signal and outputting an output signal obtained by executing a plurality of operations and a second processor for inputting an input signal and outputting an output signal obtained by executing a plurality of operations and inputs an output signal of said first processor to said second processor and the polarity of one of output signals of said second processor to be inputted to said first processor is inverted to that of said input signals to be inputted to said first processor.

[0365] Preferably the invention includes a controller wherein when one of said input signals to be inputted to said first processor makes a closed loop via said second processor, the polarity thereof is inverted.

[0366] In a third aspect, the invention may include a controller characterised in that said controller comprises a first serial converter for converting a parallel input signal to a serial signal, a first processor for processing an output signal of said first serial converter as an input signal, a first parallel converter for converting a serial output signal of said first processor to a parallel signal, a second serial converter for converting a parallel input signal to a serial signal, a second processor for processing an output signal of said second serial converter as an input signal, and a second parallel converter for converting a serial output signal of said second processor to a parallel signal and inputs one of output signals of said first parallel converter to said second serial converter for converting it serial signals together with other parallel input signals and one of parallel input signals inputted to said first serial converter inverts the polarity of one of output signals of said second parallel converter to that of other parallel input signals inputted to said first serial converter in the polarity inverter.

[0367] Preferably the invention includes a controller wherein when one of said parallel input signals inputted to said first serial converter makes a closed loop via said second serial converter, said second processor, and said second parallel converter, the polarity thereof is inverted to that of other parallel input signals inputted to said first serial converter.

[0368] In a fourth aspect, the invention may include a controller characterized in that said controller comprises a plurality of input signals which are a group of signals inputted in parallel, a first multiplexer and a second multiplexer for multiplexing said plurality of input signals to respective signals in time division, a first processor for processing a parallel output signal divided by said first multiplexer as an input signal, a first demultiplexer for integrating parallel output signals of said first processor which are divided in time, a second processor for processing a parallel output signal multiplexed by said second multiplexer as an input signal, and a second demultiplexer for integrating parallel output signals of said second processor which are divided in time and inputs one of output signals of said first demultiplexer to said second multiplexer together with other signals which are inputted in parallel and one of signals which are inputted to said first multiplexer in parallel inverts the polarity of one of output signals of said second demultiplexer to that of other signals which are inputted to said first multiplexer in parallel in the polarity inverter.

[0369] Preferably the invention includes a controller wherein when one of input signals inputted to said first multiplexer makes a closed loop via said second multiplexer, said second processor, and said second demultiplexer, the polarity thereof is inverted to that of said input signals inputted to said first multiplexer.

[0370] In a fifth aspect, the invention may include a controller characterized in that said controller comprises a plurality of processors for executing a plurality of operations and an adder for adding one output signal of one processor of said plurality of processors and an optional value and inputs input signals to said plurality of processors respectively, inputs one of output signals of a first processor among said plurality of processors to a

second processor among said plurality of processors, inputs one of output signals of said second processor to said adder, and inputs an output signal of said adder to said first processor.

[0371] In a sixth aspect, the invention may include a controller characterized in that said controller comprises a plurality of processors (N processors: N is a positive integer, 1, 2, 3, ---) for executing a plurality of operations and an adder for adding one output signal of said plurality of processors and an optional value and inputs input signals to said plurality of processors respectively, inputs one of output signals of a processor of N=1 among said plurality of processors to a processor of N=2 among said plurality of processors, inputs sequentially like one of output signals of said processor of N=2 to a processor of N=3, inputs one of output signals of a processor of N=N to said adder, and inputs an output signal of said adder to said first processor.

[0372] In a seventh aspect, the invention may include a controller characterized in that said controller comprises a first and a second processor for executing a plurality of operations, and an adder for adding one output signal of said first processor and an optional value, and a subtracter for subtracting an optional value from one output signal of said second processor and inputs input signals to said first processor and said second processor respectively, inputs one of output signals of said first processor to said adder, inputs an output signal of said adder to said second processor, inputs one of output signals of said second processor to said subtracter, and inputs an output signal of said subtracter to said first processor.

[0373] In an eighth aspect, the invention may include a controller characterized in that said controller comprises a plurality of processors (N processors: N is a positive integer, 1, 2, 3, ---) for executing a plurality of operations, a plurality of adders (M adders: M is a positive integer, 1, 2, 3, ---) for adding one output signal of said plurality of processors and an optional value, and a subtracter for subtracting an optional value from one output signal of said plurality of processors and inputs input signals to said plurality of processors respectively, inputs one of output signals of a processor of N=1 among said plurality of processors to an adder of M=1 among said plurality of adders, inputs an output signal of said adder of M=1 to a processor of N=2 among said plurality of processors, inputs an output signal of said adder of M=1 to a processor of N=2 among said plurality of processors, inputs one of output signals of a processor of N=2 among said plurality of processors to an adder of M=2 among said plurality of adders, inputs sequentially like an output signal of said adder of M=2 to a processor of N=3 among said plurality of processors, inputs one of output signals of a processor of N=N among said plurality of processors to said subtracter, and inputs an output signal of said subtracter to said first processor among said plurality of processors.

[0374] In a ninth aspect, the invention may include a controller characterized in that said controller comprises a first serial converter for converting a parallel input signal to a serial signal, a first processor for processing an output signal of said first serial converter as an input signal, a first parallel converter for converting a serial output signal of said first processor to a parallel signal, a second serial converter for converting a parallel input signal to a serial signal, a second processor for processing an output signal of said second serial converter as an input signal, and a second parallel converter for converting a serial output signal of said second processor to a parallel signal, a first status discrimination signal for discriminating the statuses of said first serial converter, said first processor, and said first parallel converter, a second status discrimination signal for discriminating the statuses of said second serial converter, said second processor, and said second parallel converter, a first failure detection signal for showing the statuses of said first serial converter, said first processor, and said first parallel converter by said first status discrimination signal, a second failure detection signal for showing the statuses of said second serial converter, said second processor, and said second parallel converter by said second status discrimination signal, a polarity inversion failure detection signal for inputting said second failure detection signal to a polarity inverter and inverting the output polarity of said second failure detection signal in said polarity inverter, a first adder for adding said first status discrimination signal and said polarity inversion failure detection signal, and a second adder for adding said second status discrimination signal and said first failure detection signal and inputs an output signal of said first adder to said first serial converter together with said parallel input signal and inputs an output signal of said second adder to said second serial converter together with said parallel input signal.

[0375] In a tenth aspect, the invention may include a controller characterized in that said controller comprises a first processor for outputting a first output signal which is obtained by inputting and processing a first input signal and a first detection signal, a second processor for outputting a second output signal which is obtained by inputting and processing a second input signal and a second detection signal, a first transmitter for transmitting said first detection signal to said second processor, and a second transmitter for transmitting said second detection signal of said second processor to said first processor, and said second processor outputs said second detection signal on the basis of said first detection signal inputted via said first transmitter, and said second transmitter outputs said second polarity inversion detection signal whose polarity is inverted to that of said first input signal to said first processor, and said first processor outputs said first detection signal on the basis of said polarity inversion signal of said second transmitter.

[0376] Preferably the invention includes a controller wherein said second transmitter has a logic unit for inverting the polarity of said second detection signal out-

putted from said second processor to that of said first input signal.

[0377] Preferably, the invention includes a controller wherein said second processor has a logic unit for inverting the polarity of said second detection signal processed on the basis of said first detection signal to that of said first input signal.

[0378] Preferably, the invention includes a controller wherein said first input signal or said second input signal has processing data of said first processor and said second processor and check data for checking the operations of said first and second processors.

[0379] Preferably, the invention includes a controller wherein the processing data of said input signal is the same as that of said second input signal.

[0380] Preferably, the invention includes a controller wherein said check data checks the content of said first processing data or said second processing data.

[0381] Preferably, the invention includes a controller wherein said first processor or said second processor has a logic unit for implementing logic for said first detection signal or said second detection signal and the check data of said input signal or said second input signal.

Claims

1. An ATP device **characterised in that** said device comprises a first logic unit including a first failure detector for checking first control data including at least two kinds of CRC data according to an ATP command speed signal for instructing the speed of an electric motor vehicle using one of said CRC data and outputting a first failure detection signal, a first frequency converter for converting said first control data to a first ATP command speed frequency signal, and a first frequency comparator for comparing a speed frequency signal in proportion to said detected speed of said electric motor vehicle and said first ATP command speed frequency signal and outputting a first output signal according to the deviation between said speed frequency signal and said first ATP command speed frequency signal, a second logic unit including a second failure detector for checking second control data including at least two kinds of CRC data according to said ATP command speed signal using one of said CRC data and outputting a second failure detection signal, a second frequency converter for converting said second control data to a second ATP command speed frequency signal, and a second frequency comparator for comparing said speed frequency signal and said second ATP command speed frequency signal and outputting a second output signal according to the deviation between said speed frequency signal and said second ATC command speed frequency signal, and a matcher for collating said first output signal and said second output signal and outputting alternating signals and changes or controls said CRC data of said second failure detector by said first failure detection signal and changes or controls said CRC data of said first failure detector by said second failure detection signal.

2. An ATP device according to Claim 1, wherein a first signal line for transmitting a signal for changing said CRC data of said second failure detector by said first failure detection signal is connected between the output side of said first failure detector and the input side of said second failure detector and a second signal line for transmitting a signal for changing said CRC data of said first failure detector by said second failure detection signal is connected between the output side of said second failure detector and the input side of said first failure detector.

3. An ATP device according to Claim 2, wherein one of said first signal line and said second signal line has a logic circuit for inverting said first or second failure detection signal.

4. An ATP device according to Claim 1 wherein said device further comprises a first microcomputer for being inputted of an ATP command speed signal for instructing the speed of an electric motor vehicle and generating first control data including at least two kinds of CRC data, a second microcomputer for being inputted of said ATP command speed signal and generating second control data including at least two kinds of CRC data, the first failure detector for checking said first control data inputted from said first microcomputer using one of said CRC data and outputting the first failure detection signal, the second failure detector for checking said second control data inputted from said second microcomputer using one of said CRC data and outputting the second failure detection signal, and said CRC data of said second control data are changed or controlled by said first failure detection signal and said CRC data of said first control data are changed or controlled by said second failure detection signal.

5. An ATP device according to Claim 4, wherein a first signal line for transmitting a signal for changing said CRC data of said second failure detector by said first failure detection signal is connected between the output side of said first failure detector and the input side of said second failure detector and a second signal line for transmitting a signal for changing said CRC data of said first failure detector by said second failure detection signal is connected between the output side of said second failure detector and the input side of said first failure detector.

6. An ATP device according to Claim 5, wherein one

of said first signal line and said second signal line has a logic circuit for inverting said first or second failure detection signal.

7. An ATP device according to Claim 4 wherein said device further comprises a generator which is installed outside an electric motor vehicle for generating an ATP command speed signal for instructing the speed of said electric motor vehicle, a receiver which is installed inside said electric motor vehicle for receiving said ATP command speed signal from said generator, a speed detector which is installed inside said electric motor vehicle for detecting the speed of said electric motor vehicle and generating a speed frequency signal in proportion to said speed, and the ATP device which is installed inside said electric motor vehicle for controlling the speed of said electric motor vehicle from said ATP command speed signal and said speed frequency signal, wherein the first microcomputer for being inputted of said ATP command speed signal outputted from said receiver and generating the first control data including at least two kinds of CRC data, a second microcomputer for being inputted of said ATP command speed signal outputted from said receiver and generating the second control data including at least two kinds of CRC data, the first failure detector for checking said first control data inputted from said first microcomputer using one of said CRC data and outputting the first failure detection signal, the second failure detector for checking said second control data inputted from said second microcomputer using one of said CRC data and outputting the second failure detection signal, the matcher for being inputted of said first failure detection signal, said first output signal, said second failure detection signal, and said second output signal, collating said first output signal and said second output signal on the basis of said first and second failure detection signals, and outputting alternating signals in which said first output signal and said second output signal alternate, and further comprises a braking device which is installed inside said electric motor vehicle for inputting said alternating signals, controlling the braking force, and driving the brake.

8. An ATP device according to Claim 7, wherein a first signal line for transmitting a signal for changing said CRC data of said second failure detector by said first failure detection signal is connected between the output side of said first failure detector and the input side of said second failure detector and a second signal line for transmitting a signal for changing said CRC data of said first failure detector by said second failure detection signal is connected between the output side of said failure second detector and the input side of said first failure detector.

9. An ATP device according to Claim 8, wherein one of said first signal line and said second signal line has a logic circuit for inverting said first or second detection signal.

10. An ATP device according to Claim 1 wherein said device further comprises a first microcomputer for being inputted of an ATP command speed signal for instructing the speed of an electric motor vehicle and generating first control data with first CRC data added and second control data with second CRC data added, a second microcomputer for generating third control data with third CRC data added and fourth control data with fourth CRC data added, the first logic unit further including a first memory for storing said first control data outputted from said first microcomputer, a second memory for storing said second control data, a first switching circuit for switching said first memory and said second memory, a first failure detector and a second failure detector for checking output data of said first switching circuit, a first adder for adding said output data of said first switching circuit and an output signal of said second failure detector, a second adder for adding the speed frequency signal in proportion to the speed of said electric motor vehicle and an output signal of said first failure detector, the first frequency converter converts an output signal of said first adder to the ATP command speed frequency signal, and the first frequency comparator compares an output signal of said second adder and an output signal of said first frequency converter and outputting the first output signal and a first failure detection signal according to the deviation therebetween, the second logic unit further including a third memory for storing said third control data outputted from said second microcomputer, a fourth memory for storing said fourth control data, a second switching circuit for switching said third memory and said fourth memory, a third failure detector and a fourth failure detector for checking output data of said second switching circuit, a third adder for adding said output data of said second switching circuit and an output signal of said fourth failure detector, a fourth adder for adding the speed frequency signal in proportion to the speed of said electric motor vehicle and an output signal of said third failure detector, the second frequency converter converts an output signal of said third adder to the ATP command speed frequency signal, and the second frequency comparator compares an output signal of said fourth adder and an output signal of said second frequency converter and outputting the second output signal and a second failure detection signal according to the deviation therebetween, and the matcher for collating said first output signal of said first logic unit, said second output signal of said second logic unit, said first failure detection signal, and

said second detection signal respectively and outputting alternating signals, and said first failure detection signal controls said second switching circuit and switches said third control data and said fourth control data and said second failure detection signal controls said first switching circuit and switches said first control data and said second control data.

11. An ATP device according to Claim 10, wherein said device has a logic circuit for inverting the polarity of one of said second failure detection signal for controlling said first switching circuit and said first failure detection signal for controlling said second switching circuit.

12. An ATP device according to Claim 10, wherein said first microcomputer generates said first control data, said first CRC data for said first control data, and said second CRC data for said first control data when said ATP command speed signal for instructing the speed of an electric motor vehicle is inputted, and said second microcomputer generates said second control data, said third CRC data for said second control data, and said fourth CRC data for said second control data when said ATP command speed signal for instructing the speed of an electric motor vehicle is inputted, and an output signal of a fifth adder for adding said first control data and said first CRC data and an output signal of a sixth adder for adding said first control data and said second CRC data are inputted to said first switching circuit, and an output signal of a seventh adder for adding said second control data and said third CRC data and an output signal of an eighth adder for adding said second control data and said fourth CRC data are inputted to said second switching circuit.

13. AN ATP device according to Claim 10, wherein said first microcomputer generates said first control data with said first CRC data and said second CRC data added when said ATP command speed signal for instructing the speed of an electric motor vehicle is inputted, and said second microcomputer generates said second control data with said third CRC data and said fourth CRC data added when said ATP command speed signal for instructing the speed of an electric motor vehicle is inputted, and said first control data outputted from said first microcomputer is stored in said first memory, and an output signal of said first memory is inputted to said first failure detector, said second failure detector, and said first adder, said second control data outputted from said second microcomputer is stored in said second memory, and an output signal of said second memory is inputted to said third failure detector, said fourth failure detector, and said third adder, and said second switching circuit switches said third CRC data and said fourth CRC data by said first failure detection signal, and said first switching circuit switches said first CRC data and said second CRC data by said second failure detection signal.

14. An ATP device according to Claim 10, wherein said first microcomputer generates the first control data, said first CRC data, and said second CRC data when said ATP command speed signal for instructing the speed of an electric motor vehicle is inputted, and said second microcomputer generates the second control data, said third CRC data, and said fourth CRC data when said ATP command speed signal for instructing the speed of an electric motor vehicle is inputted, and said first CRC data and said second CRC data are inputted to said first switching circuit, and an output signal of said first switching circuit and said first control data are added to a fifth adder, and said third CRC data and said fourth CRC data are inputted to said second switching circuit, and an output signal of said second switching circuit and said second control data are added to a sixth adder, and an output signal of said fifth adder is inputted to said first adder, said first failure detector, and said second failure detector, and an output signal of said sixth adder is inputted to said third adder, said third failure detector, and said fourth failure detector.

15. An ATP device according to one of claims 1 to 14, wherein an accident diagnosis processing operation is executed periodically after a parallel input signal is processed.

16. A controller according to one of claims 1 to 14, wherein said input signal, said output signal, and said failure detection signal are alternating signals which alternate when said plurality of processors are all normal.

17. An ATP device according to one of claims 4, 7 and 10, wherein said matcher collates said first output signal, said second output signal, said first failure detection signal, and said second failure detection signal, and when said first and second output signals do not match with each other and said first and second failure detection signals do not match with each other, the alternation is stopped, and an emergency brake signal is outputted to said electric motor vehicle by stopping of the alternation when said first and second failure detection signals do not match with each other.

FIG. 1

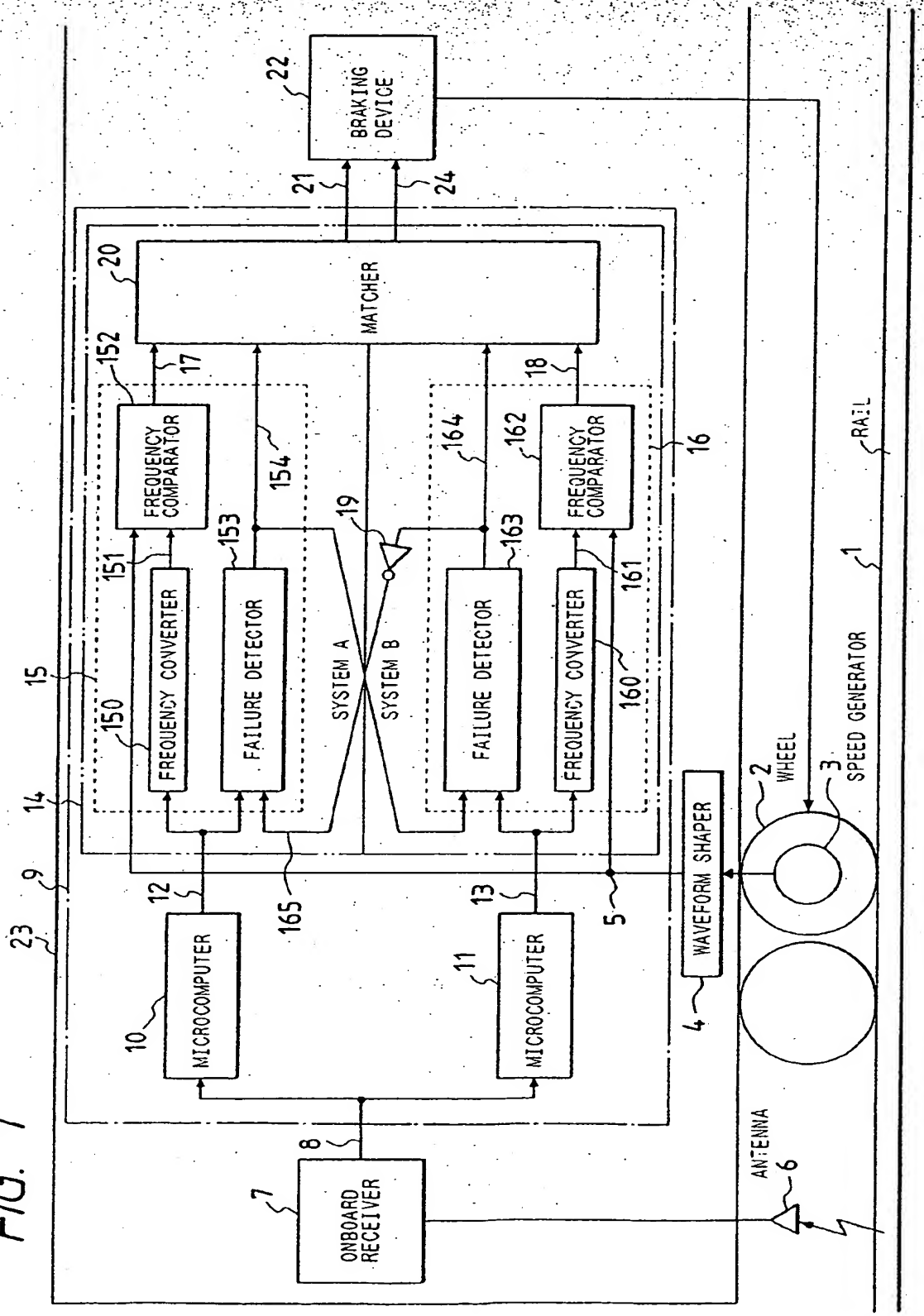


FIG. 2

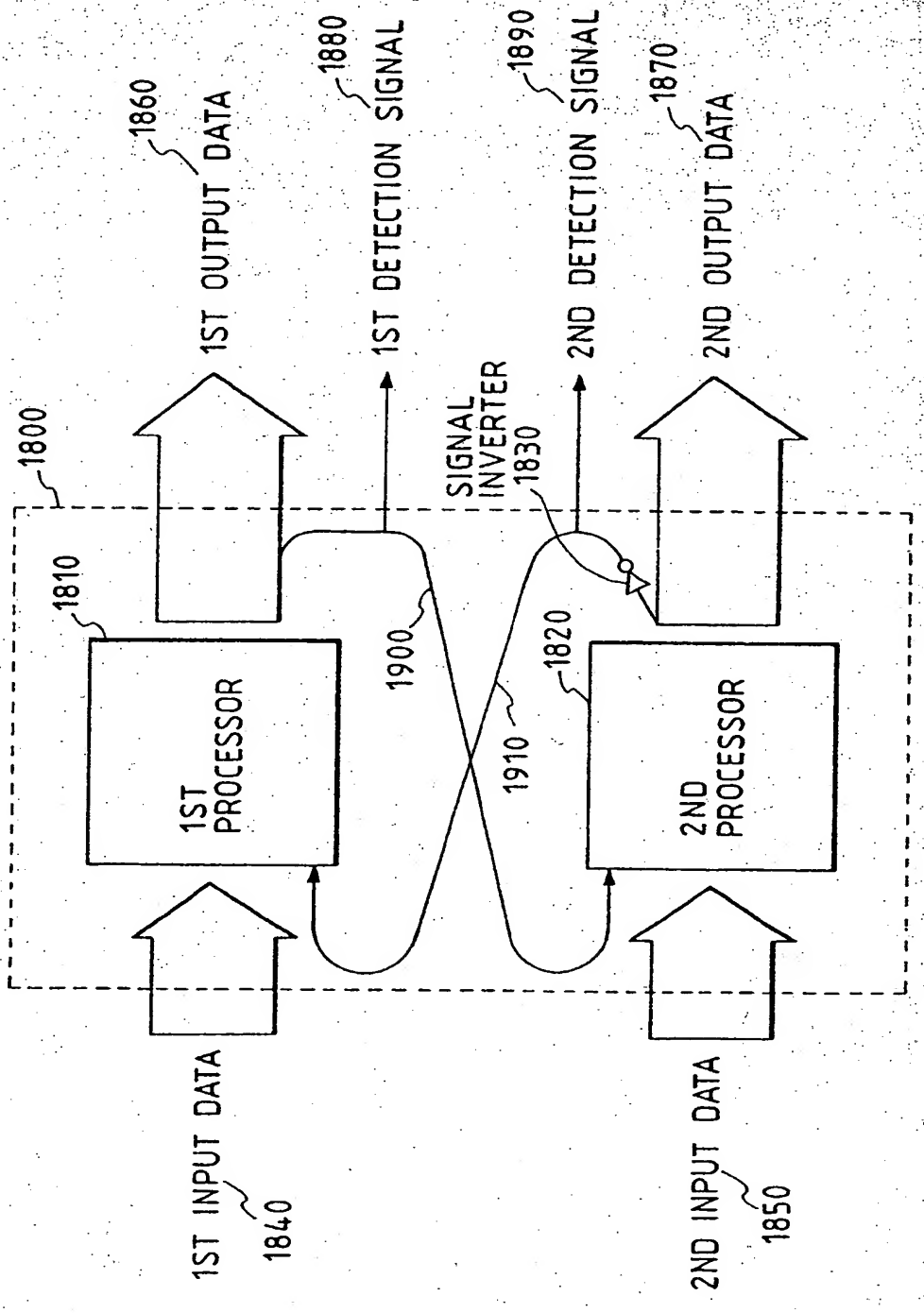

1800
1810
1820
1860
1880
1890
1870
1900
1910
1830
1840
1850
1ST OUTPUT DATA
1ST DETECTION SIGNAL
2ND DETECTION SIGNAL
2ND OUTPUT DATA
SIGNAL INVERTER
1ST PROCESSOR
2ND PROCESSOR
1ST INPUT DATA
2ND INPUT DATA

FIG. 3

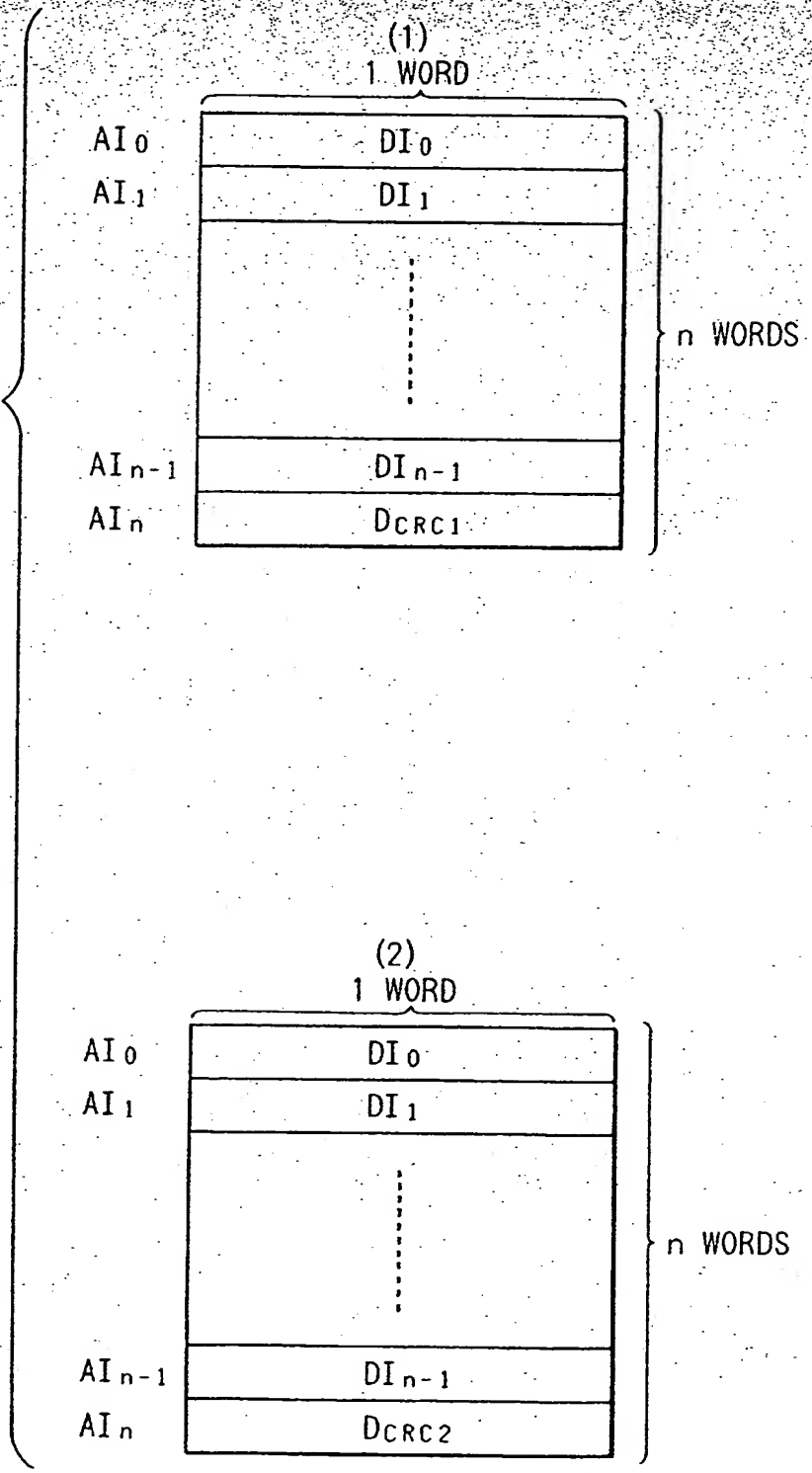


FIG. 4

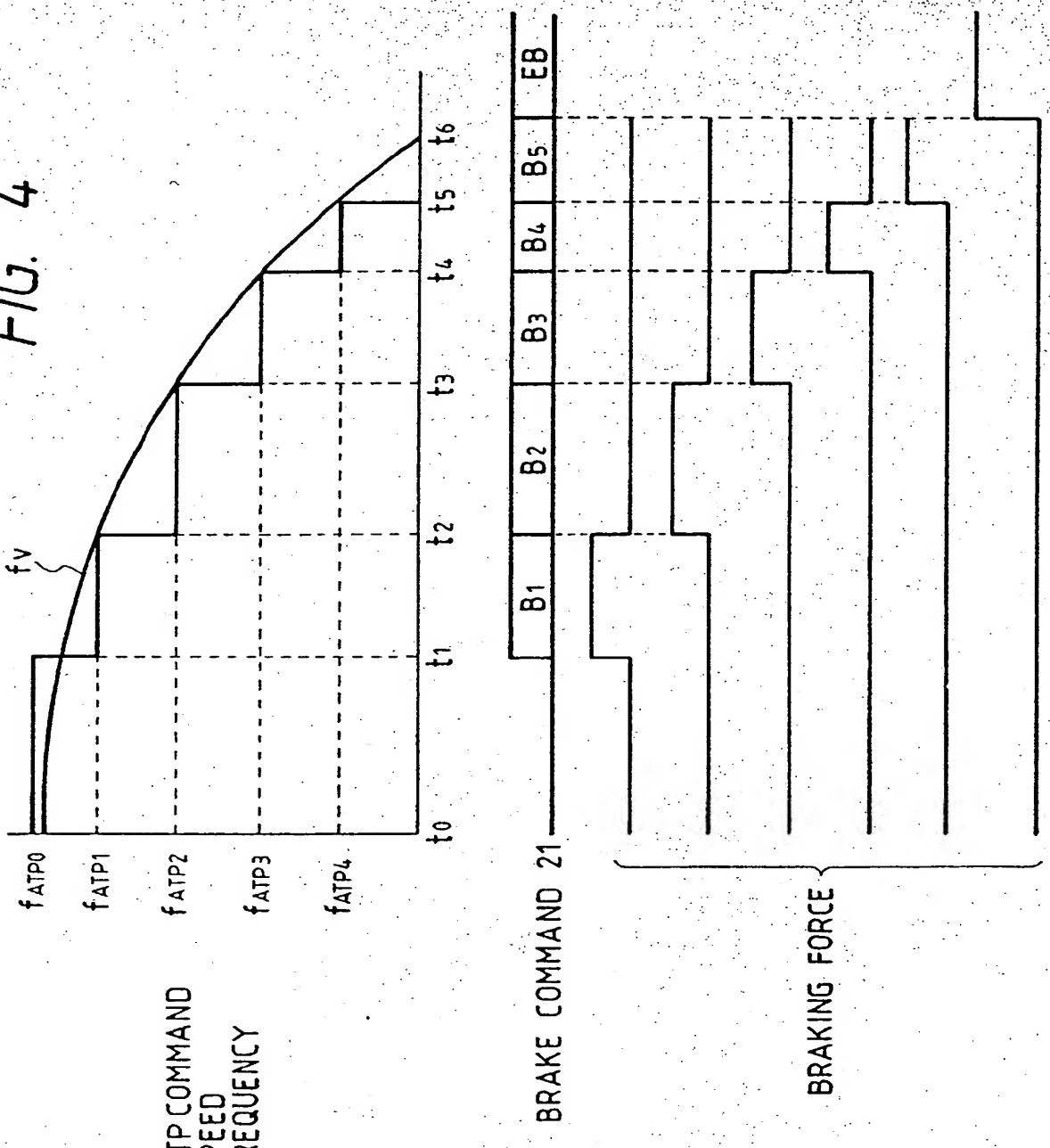

ATP COMMAND SPEED FREQUENCY
f_{ATP0}
f_{ATP1}
f_{ATP2}
f_{ATP3}
f_{ATP4}
f_V
t_0
t_1
t_2
t_3
t_4
t_5
t_6
BRAKE COMMAND 21
B1
B2
B3
B4
B5
EB
BRAKING FORCE

FIG. 5

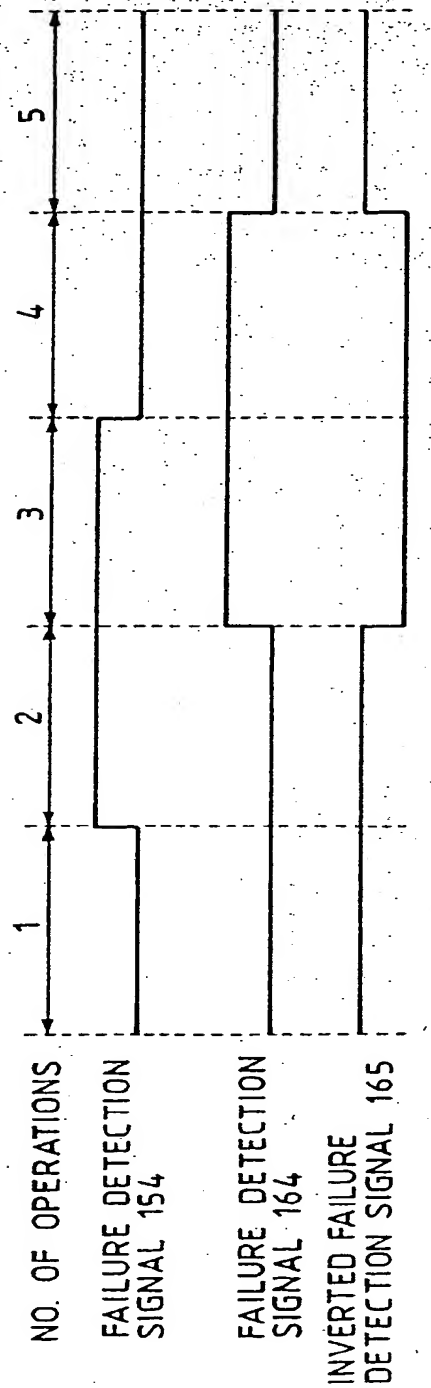


FIG. 6

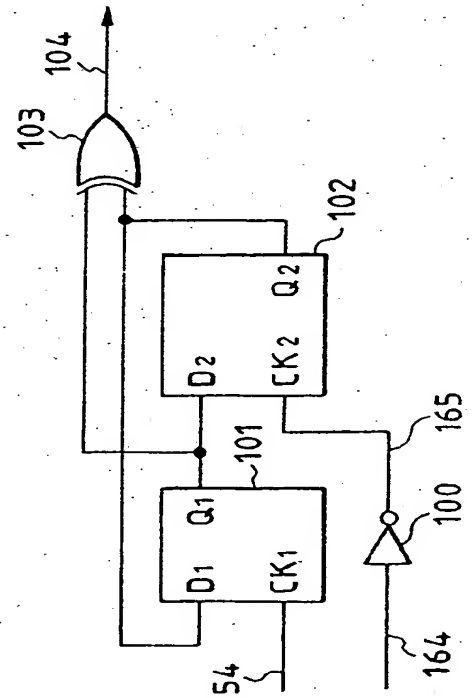


FIG. 7

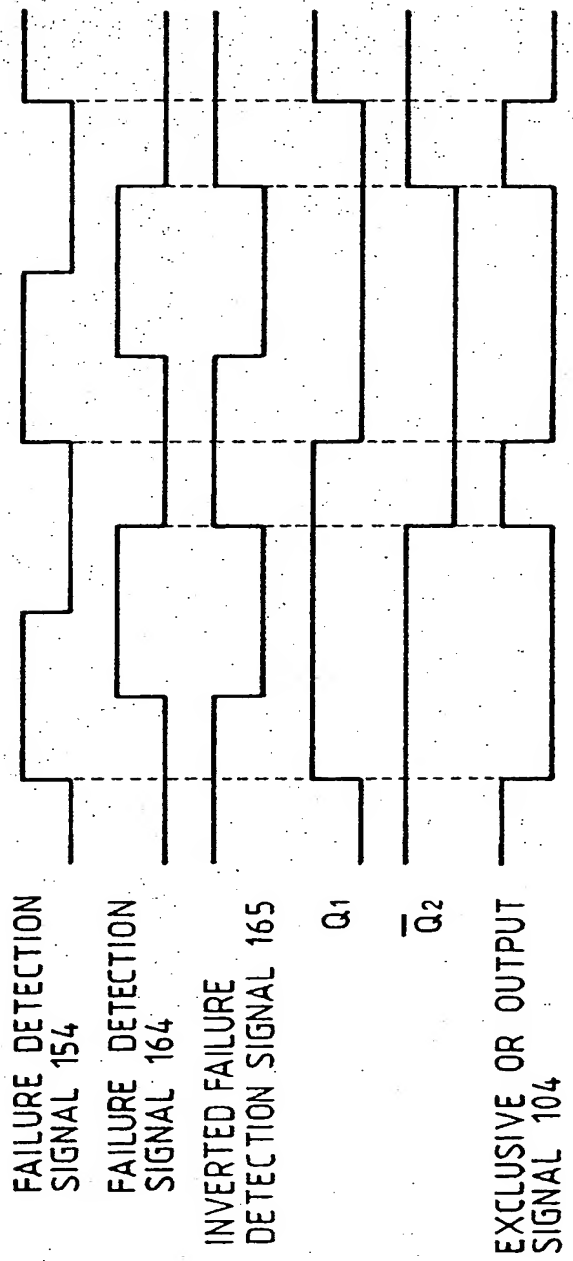

FAILURE DETECTION SIGNAL 154
FAILURE DETECTION SIGNAL 164
INVERTED FAILURE DETECTION SIGNAL 165
Q_1
$\overline{Q}_2$
EXCLUSIVE OR OUTPUT SIGNAL 104

FIG. 8

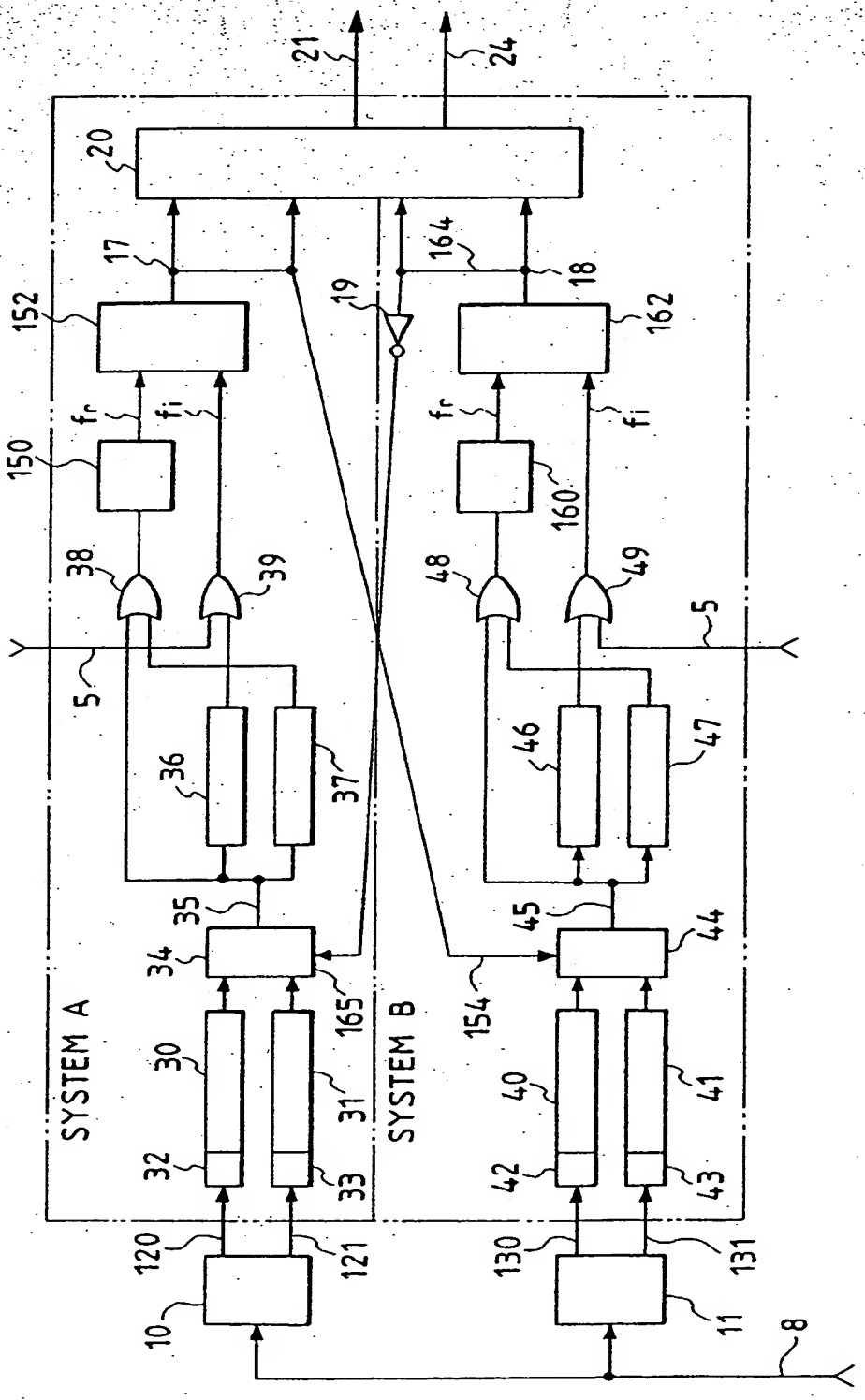


FIG. 9

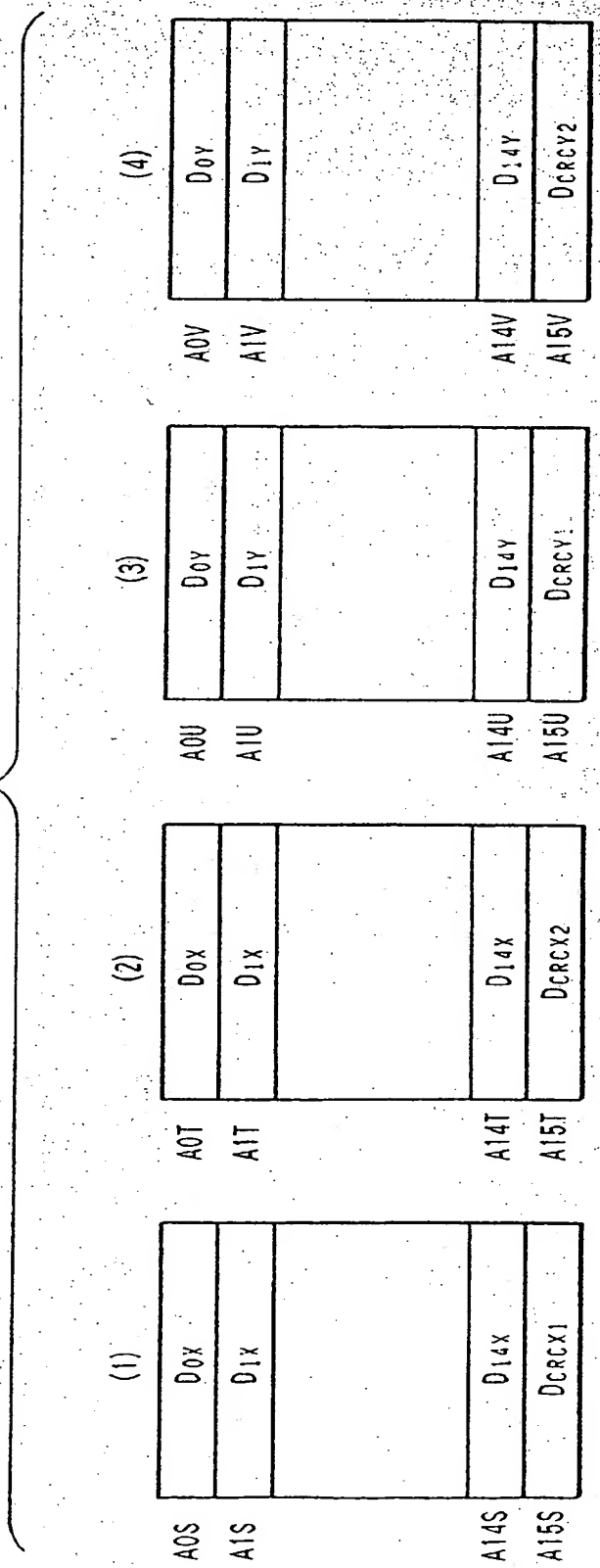


FIG. 10

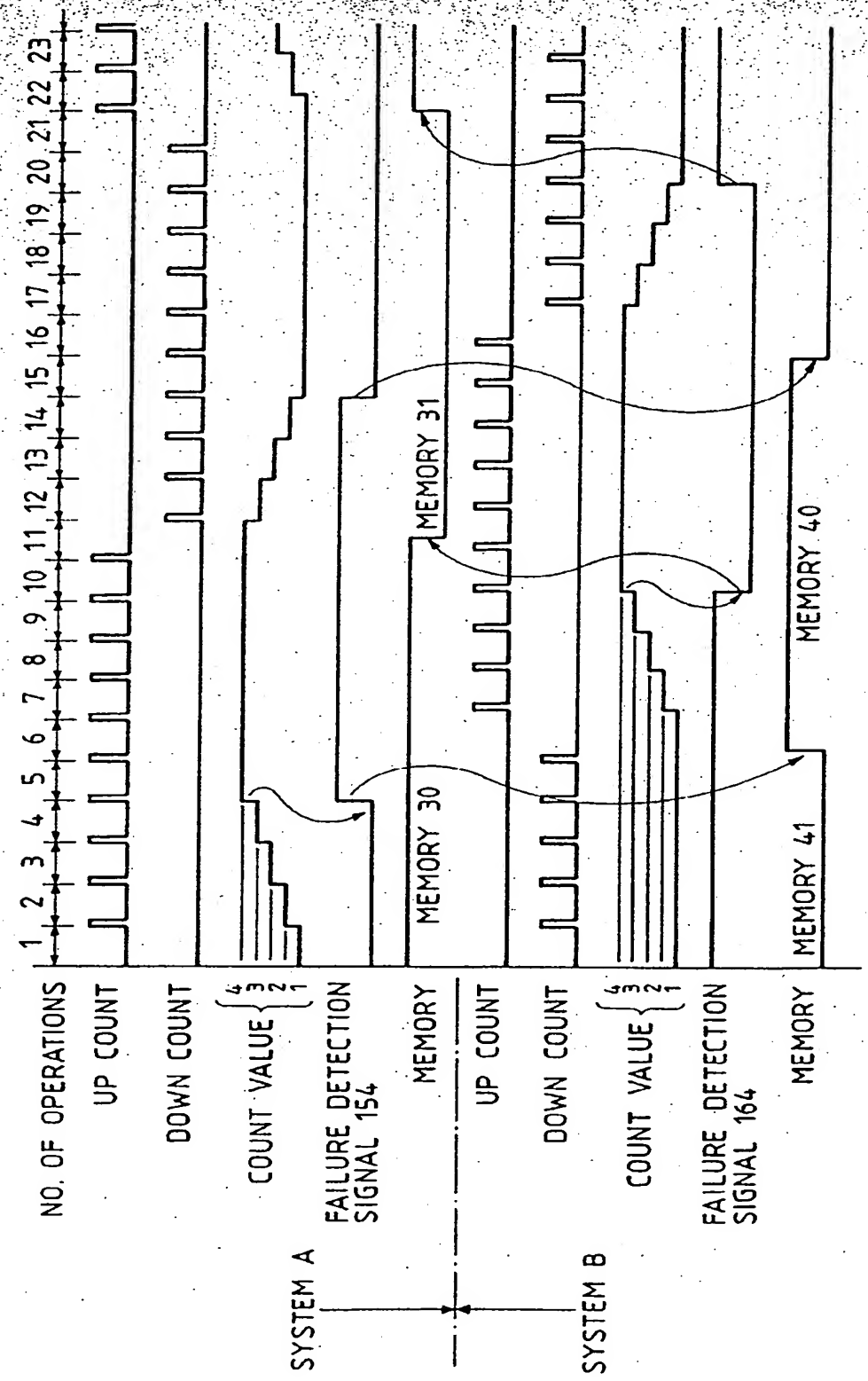


FIG. 11

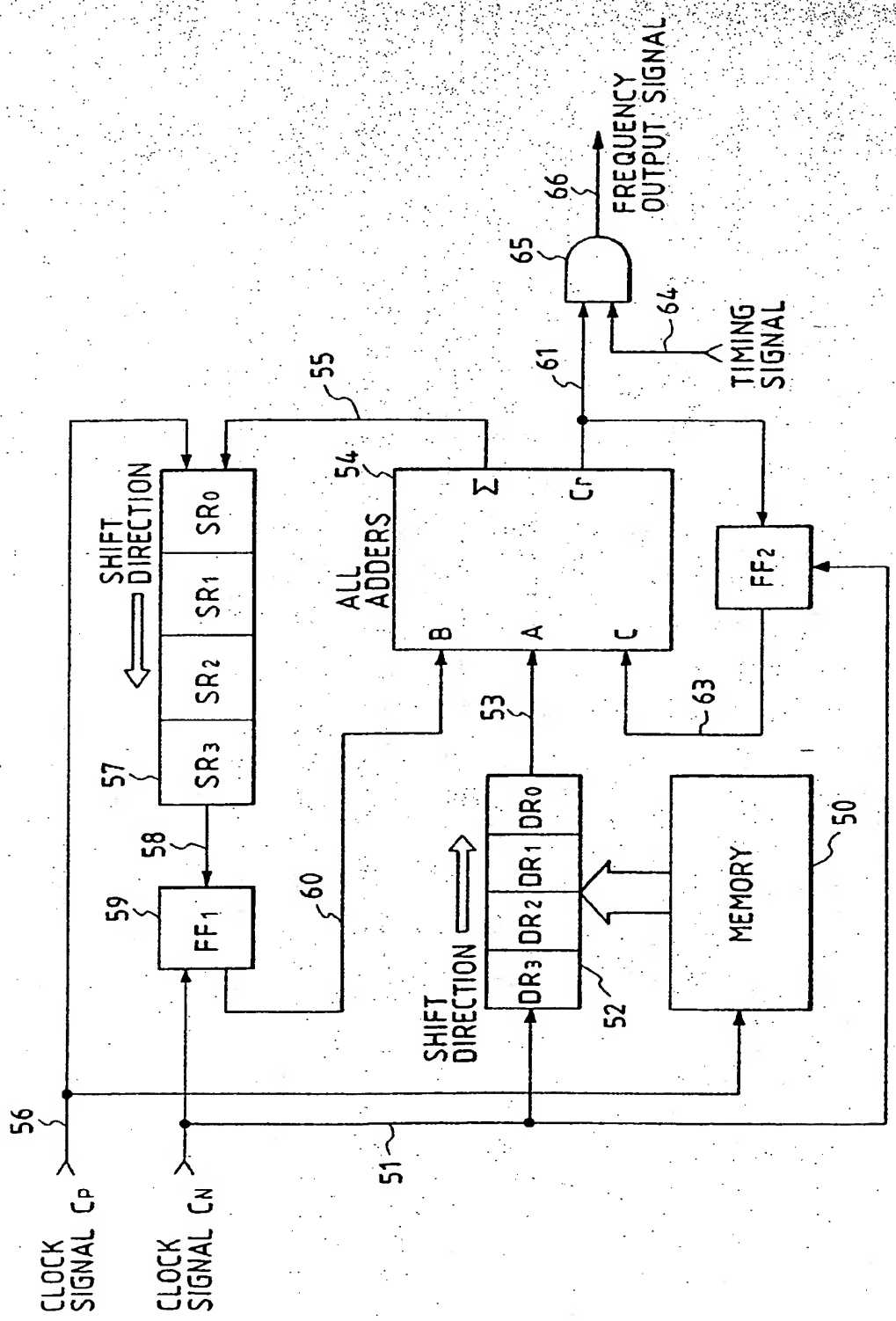


FIG. 12

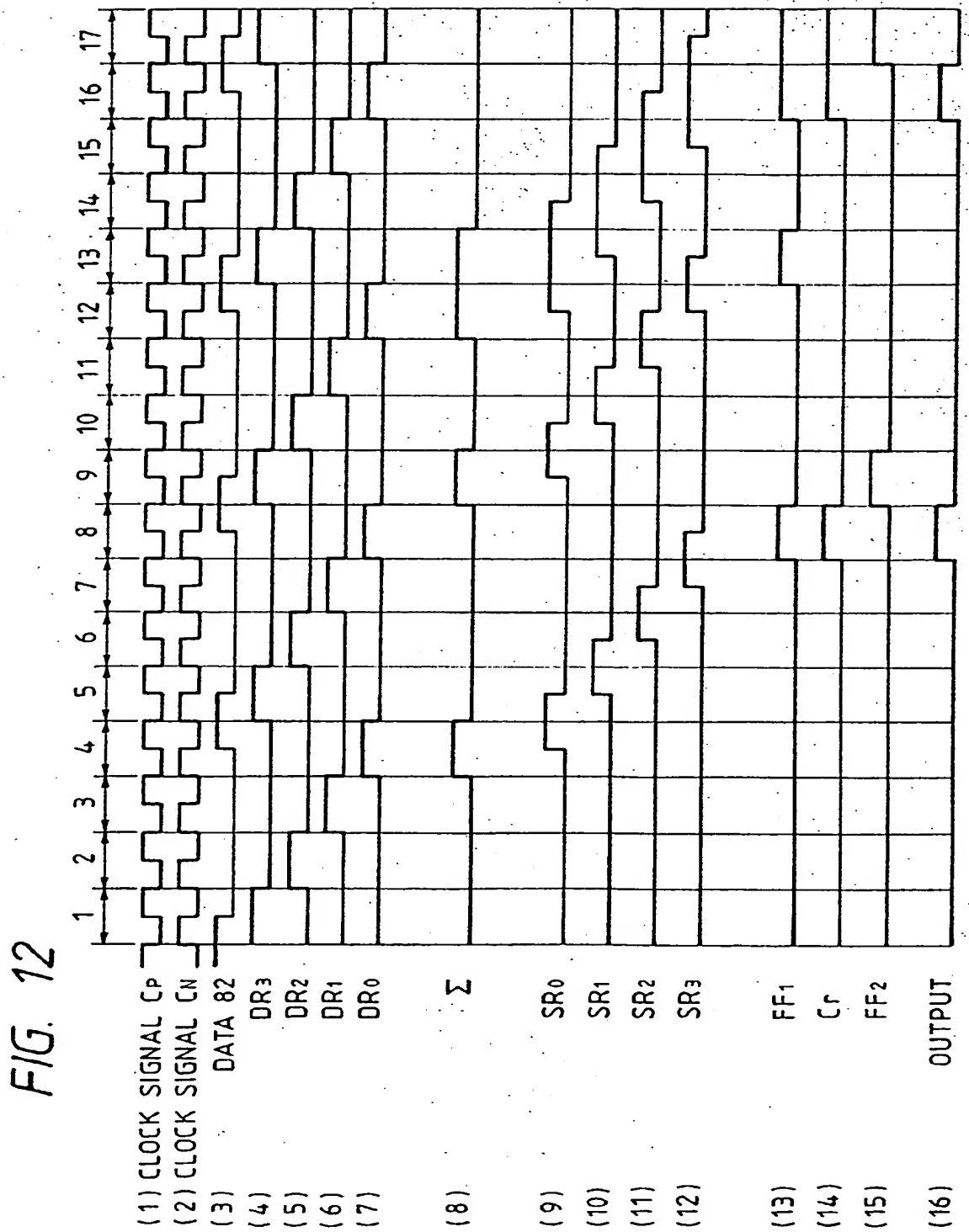


FIG. 13

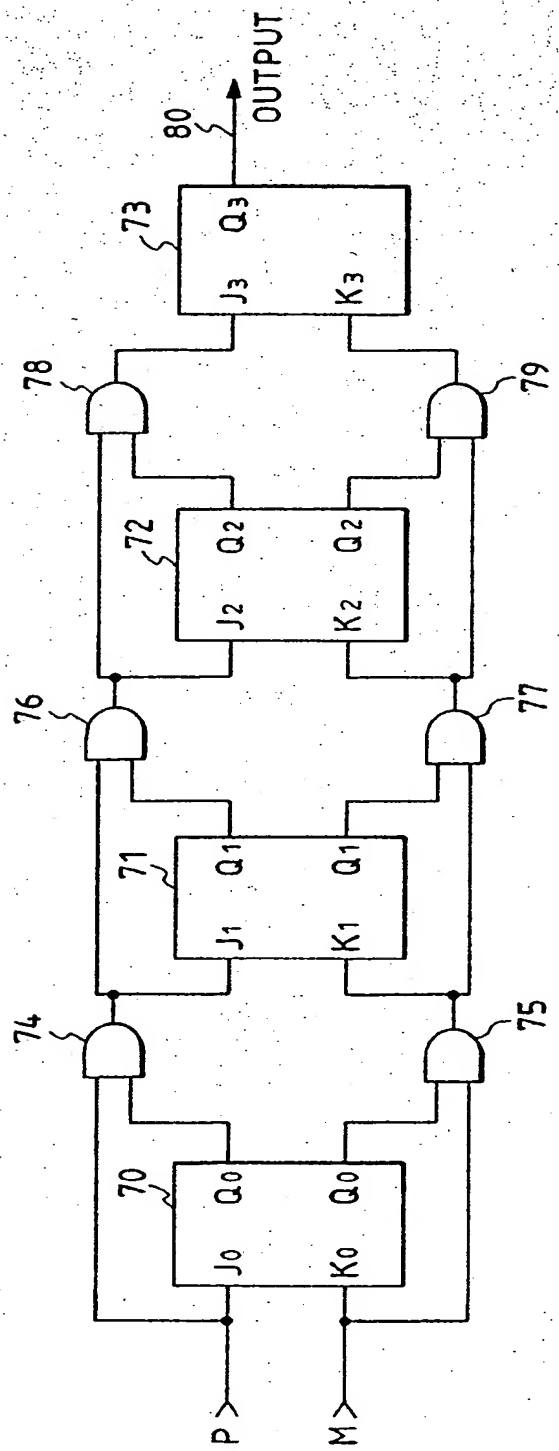


FIG. 14

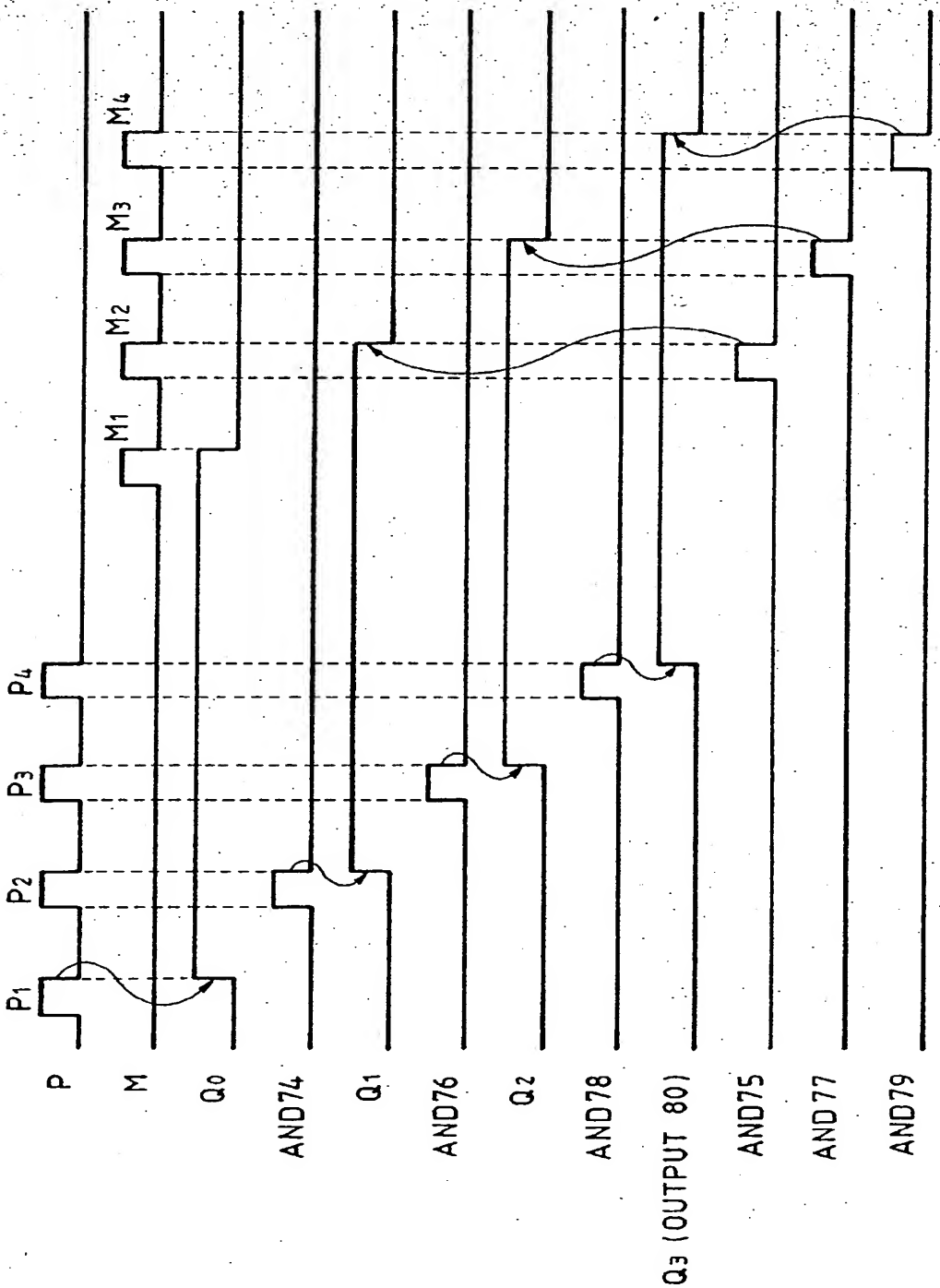


FIG. 15

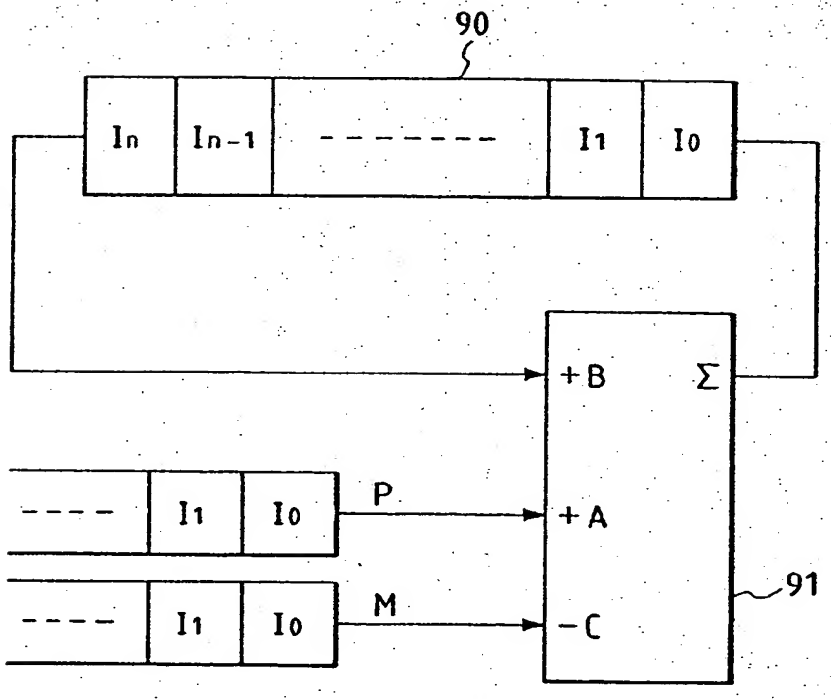


FIG. 16

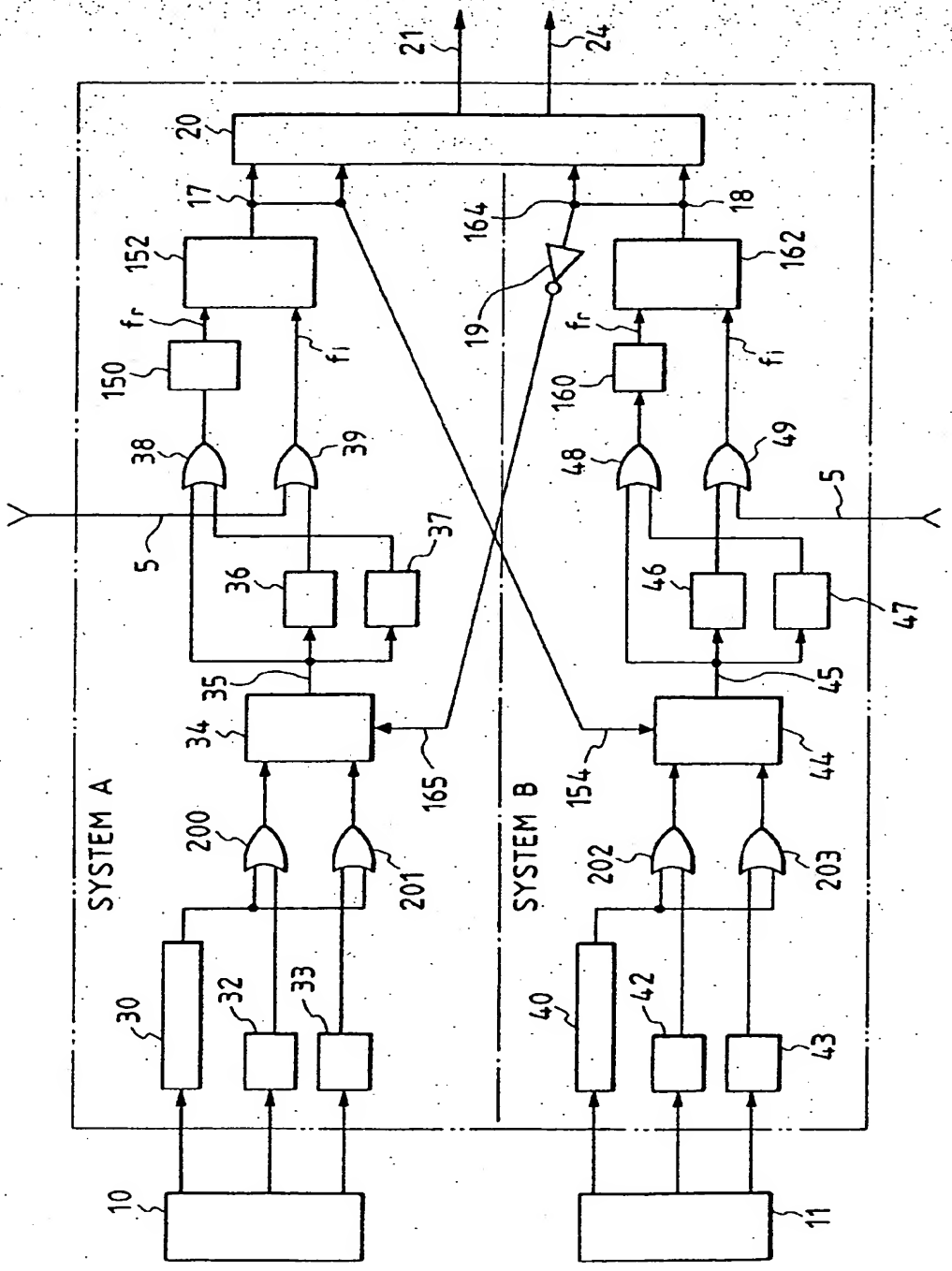


FIG. 17

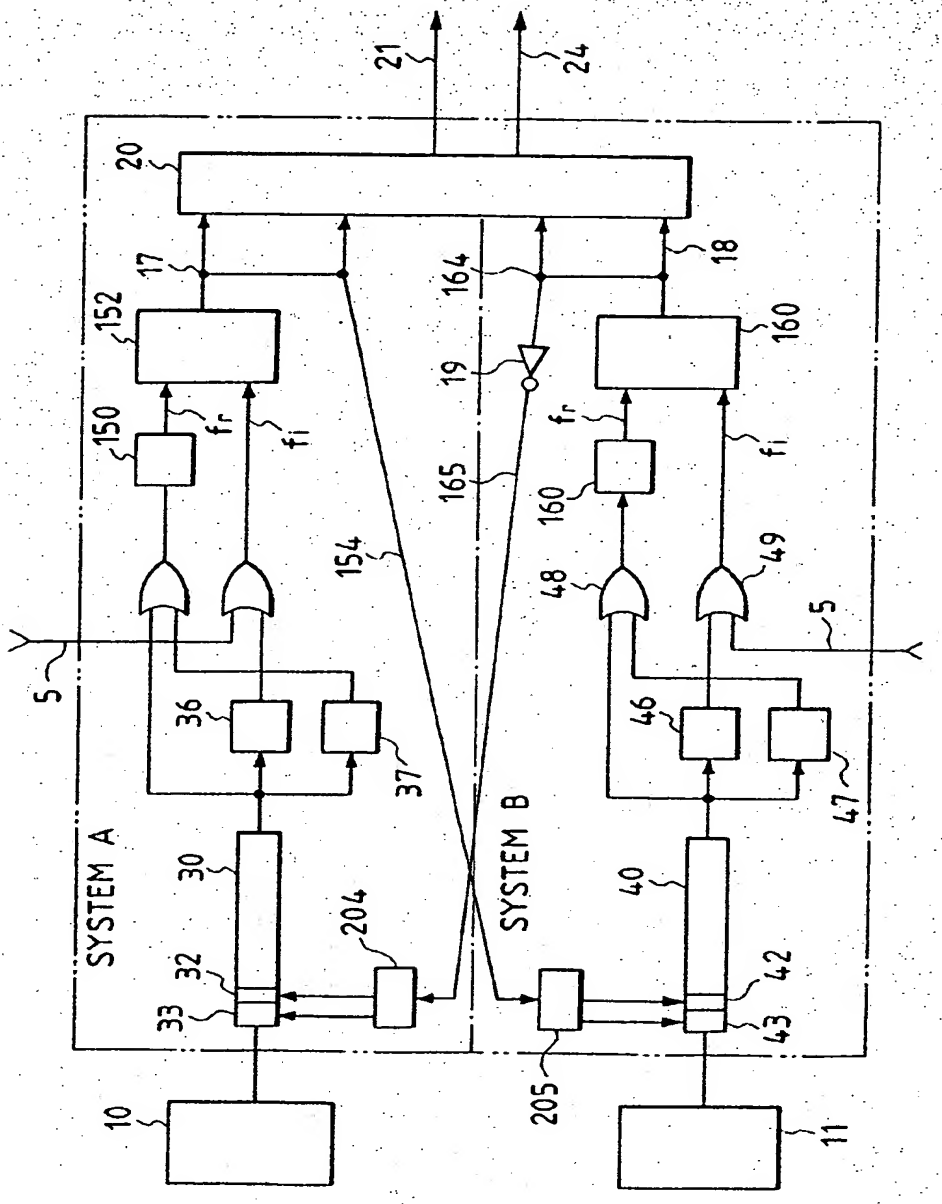


FIG. 18

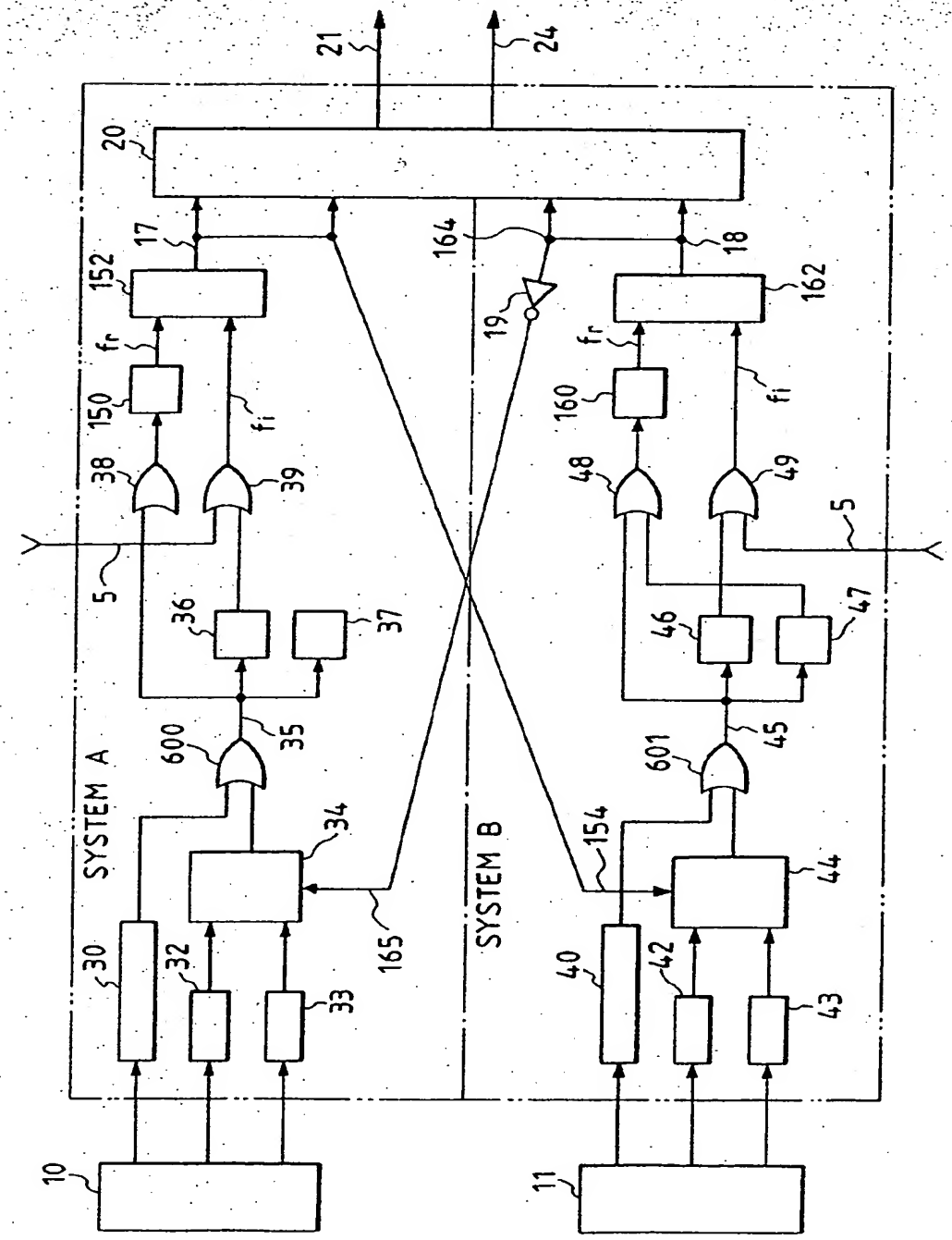


FIG. 19

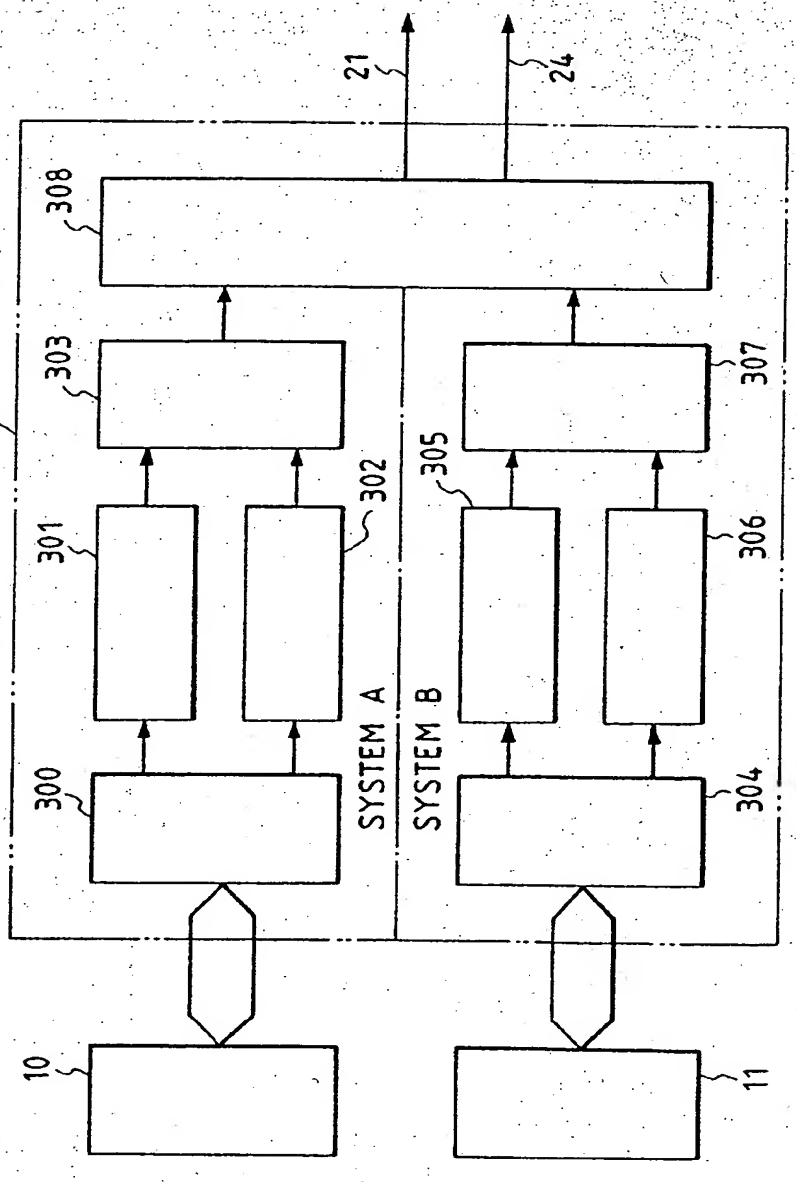

21
24
308
303
307
14
305
302
301
306
SYSTEM A
SYSTEM B
300
304
10
11

FIG. 20

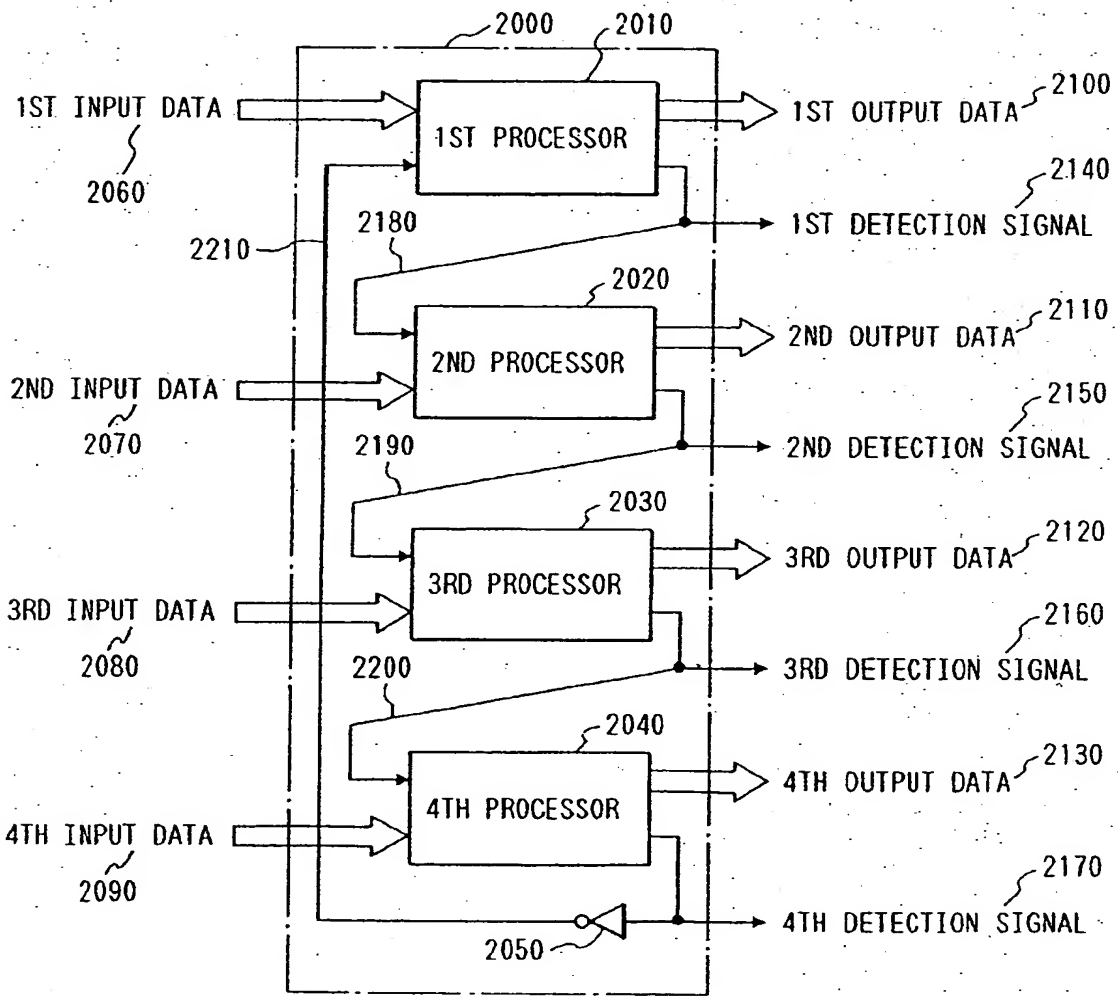


FIG. 21

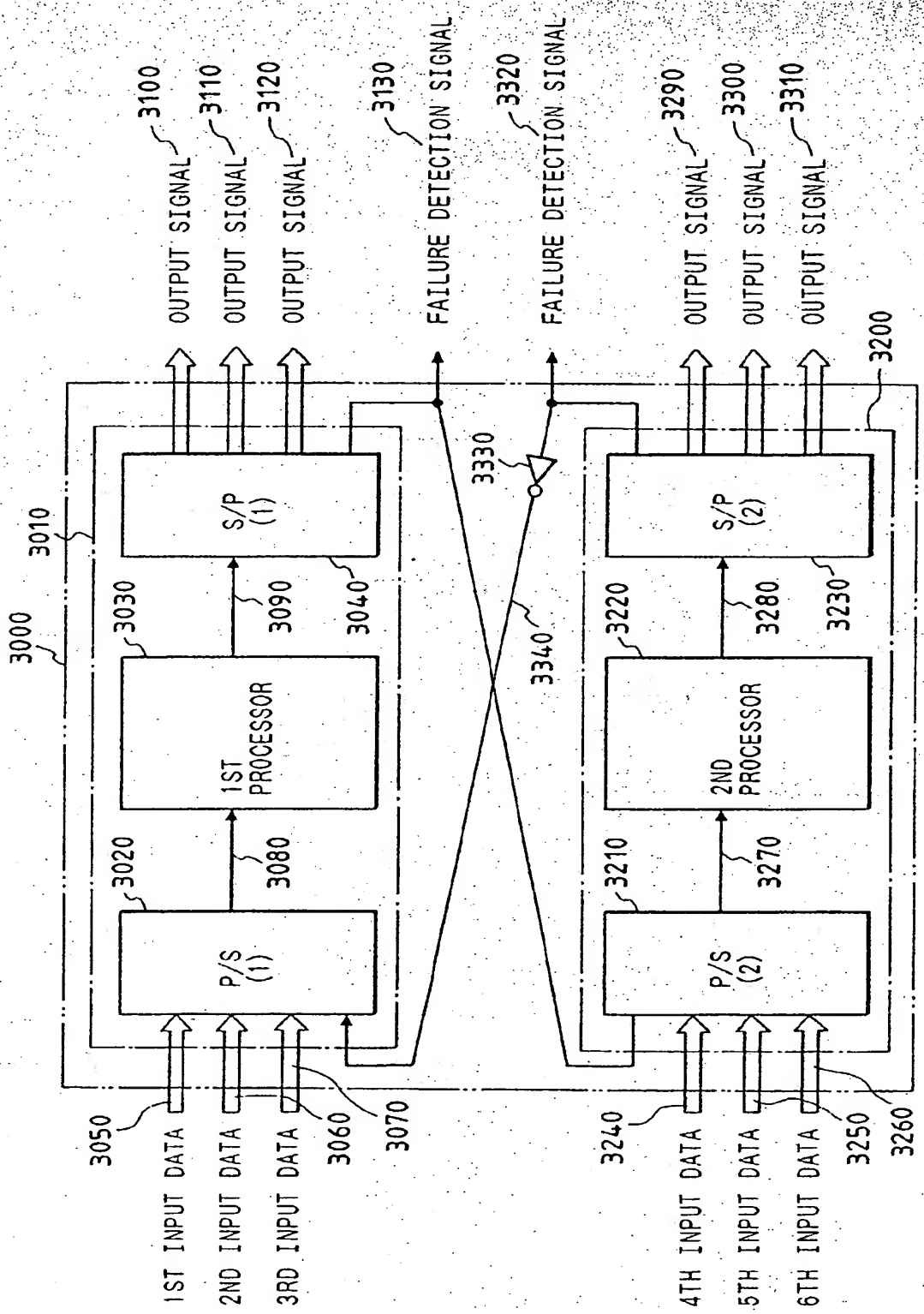


FIG. 22

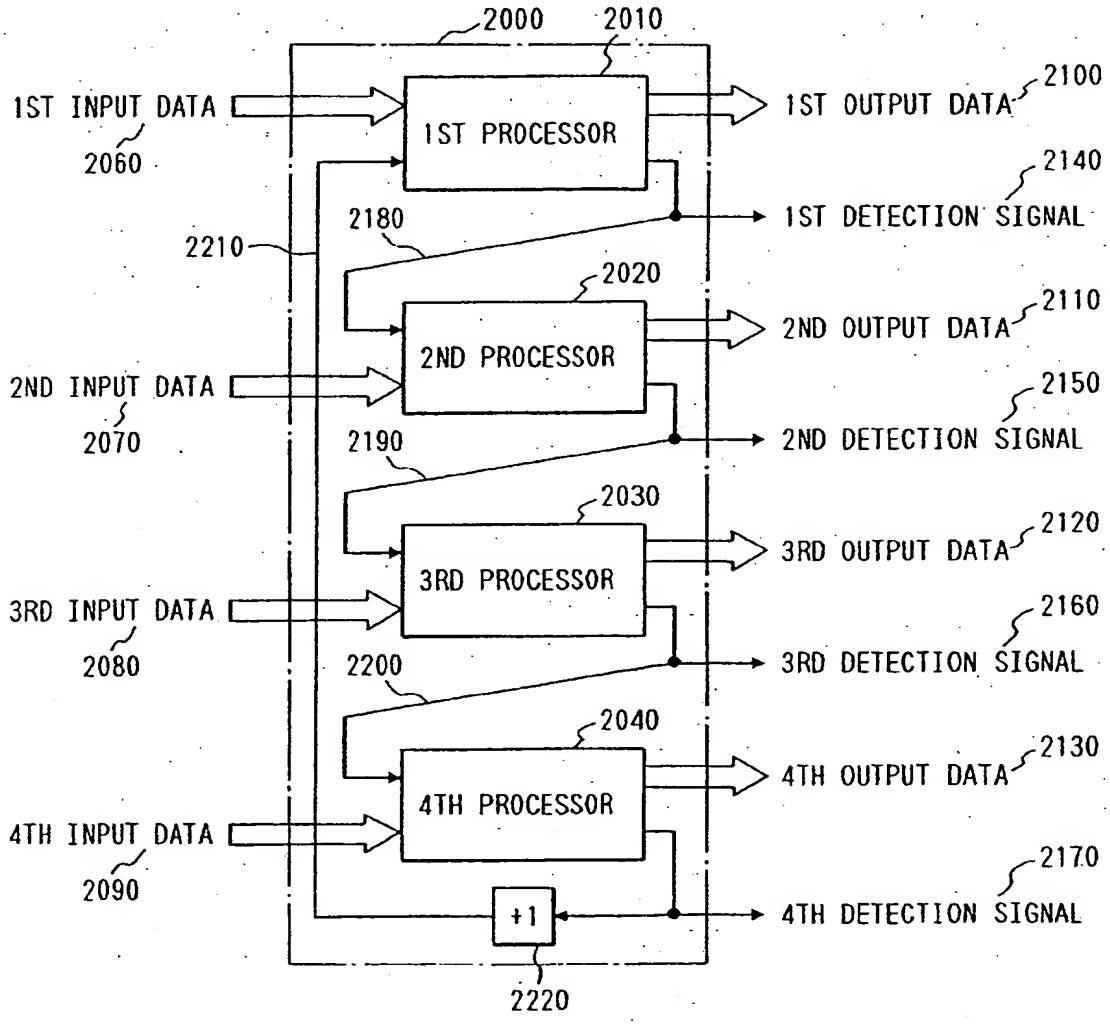


FIG. 23

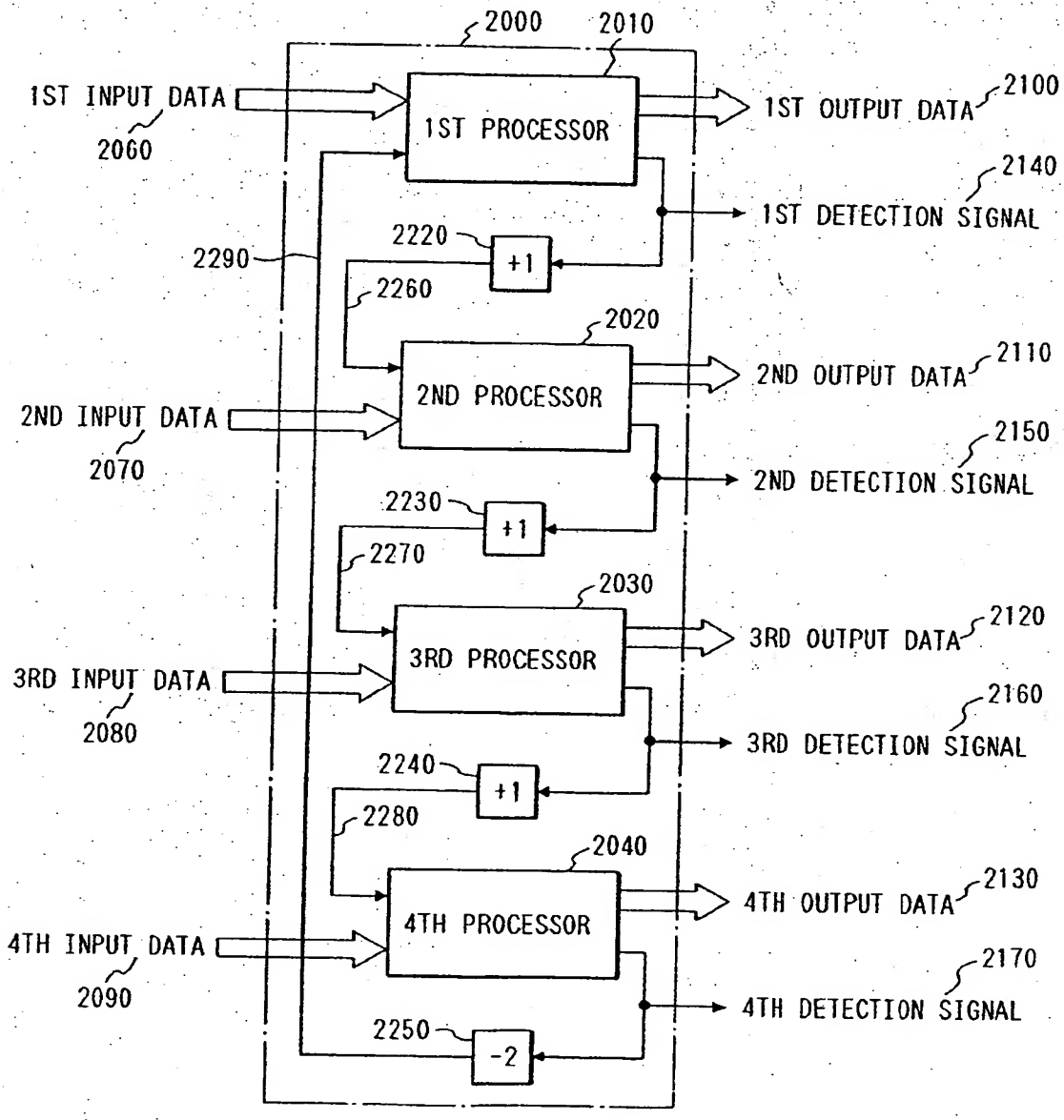


FIG. 24

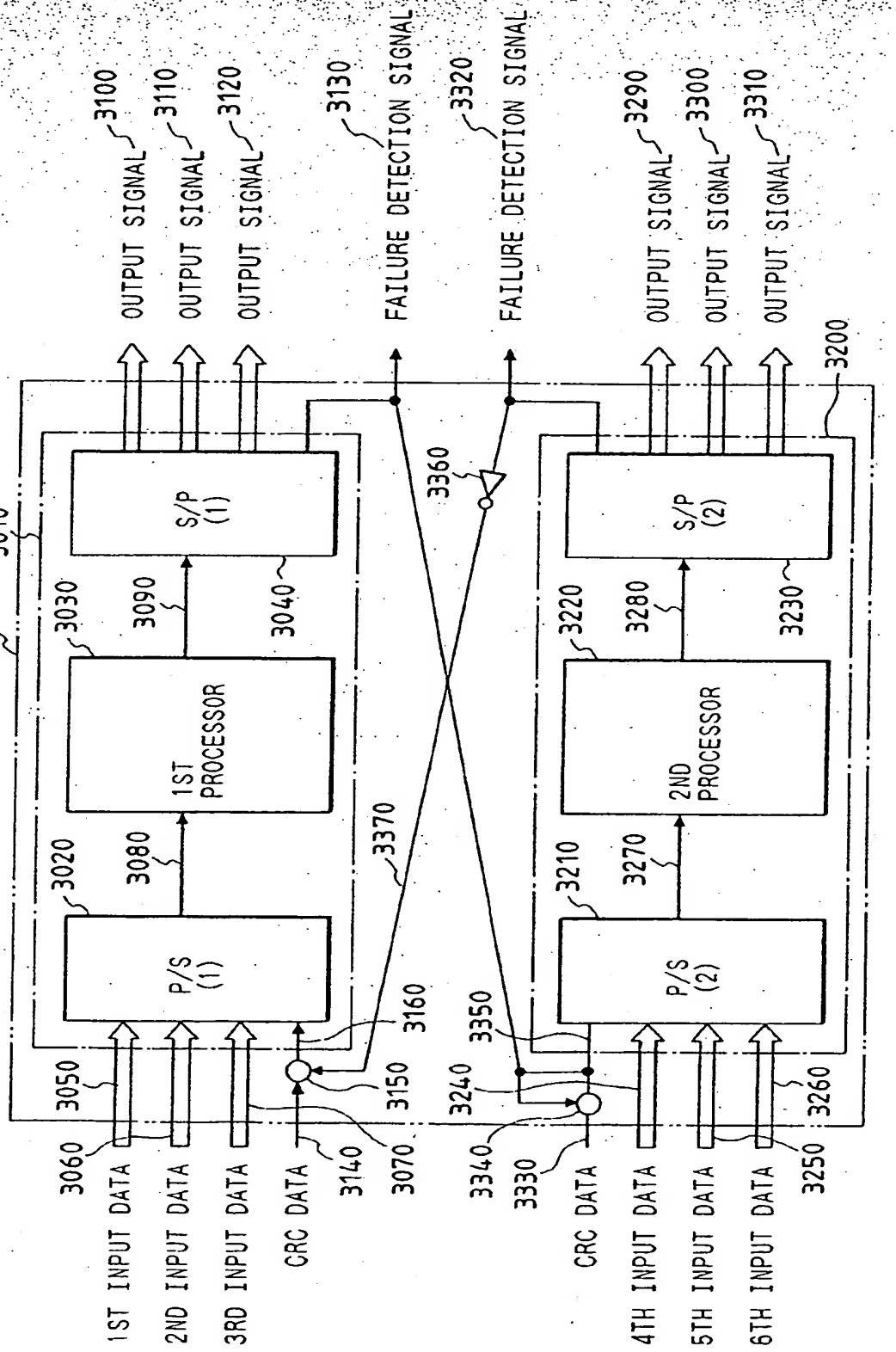
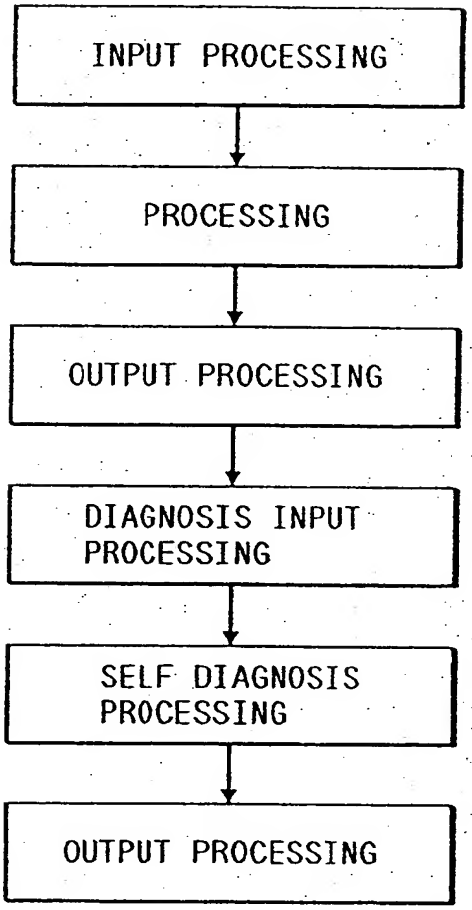


FIG. 25


INPUT PROCESSING
PROCESSING
OUTPUT PROCESSING
DIAGNOSIS INPUT PROCESSING
SELF DIAGNOSIS PROCESSING
OUTPUT PROCESSING

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European Patent Office
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(11) EP 1 302 382 A3

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20.07.1995 JP 18380395

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95309297.0 / 0 719 689

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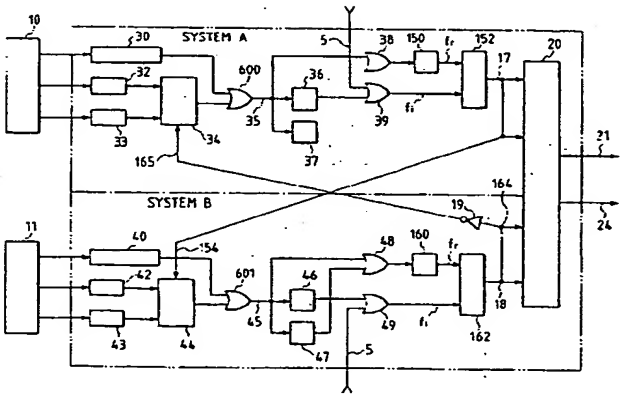
London WC2B 6HP (GB)

(54) Controller having a fail safe function, automatic train controller, and system using the same

(57) The object of the present invention is to provide a controller and a system having a highly reliable fail safe function. An ATP device which generates control data for the two systems from an ATP command speed signal, duplicates the logic unit in the ATP device so as to process each control data, provides at least two CRC data for checking the control data for each system, and changes the CRC data of the opposite logic units or selects one of the two according to the content of a failure detection signal from each of the duplicated logic units. It is realized to check the control data and the operation of each logic circuit and only when all the data, circuits, and elements operate normally, an output signal for controlling the object to be controlled is outputted and when a failure is detected in a part, an output signal is outputted. Therefore, when a failure occurs, a fail safe function for controlling on the safety side is made possible.

FIG. 18



EP 1 302 382 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 02 5389

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	GB 2 167 886 A (WESTINGHOUSE ELECTRIC CORP) 4 June 1986 (1986-06-04) * page 1, line 9 - line 27 * ---	1-14,17	B61L3/00 G06F11/00 G06F11/16
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A	US 4 400 792 A (STRELOW HORST) 23 August 1983 (1983-08-23) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B61L
G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 August 2003	Reekmans, M

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